MS-118

project
mercury

OPERATION AND MAINTENANCE

ACQUISITION SYSTEM WHITE SANDS, NEW MEXICO

prepared for
National Aeronautics and Space Administration
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The Bendix Corporation
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in association with

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WARNING

The equipment described in this manual employs voltages which are dangerous. Use appropriate caution when working on this equipment.

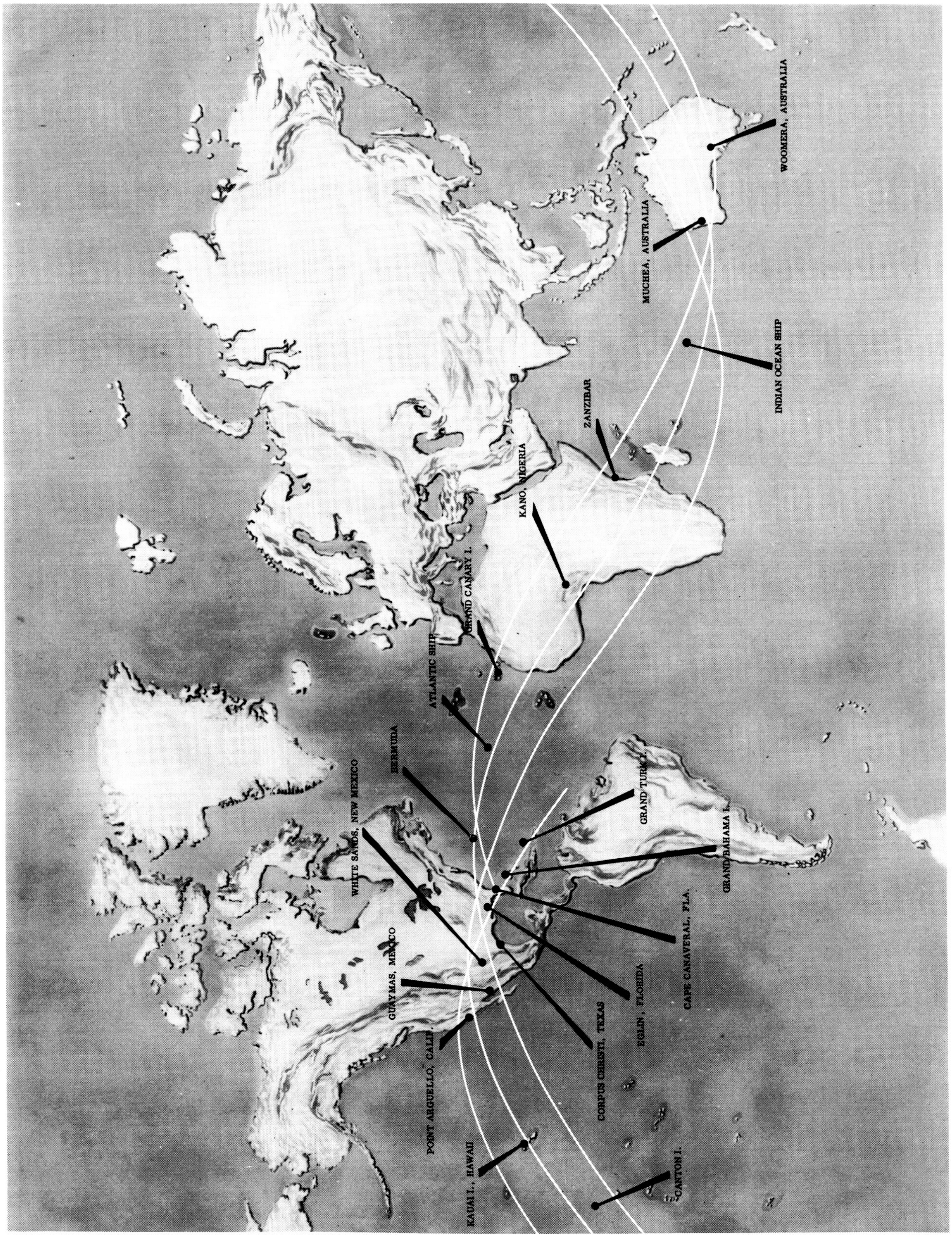


Figure 1-1. Locations of Project Mercury Sites

SECTION I
GENERAL DESCRIPTION

1-1. GENERAL INFORMATION

A. SCOPE OF MANUAL

This publication comprises operating and service instructions for the acquisition system which forms a part of the Mercury ground instrumentation at White Sands, New Mexico.

B. PROJECT MERCURY SCOPE

(1). The prime objective of Project Mercury is manned orbital flight with a safe return of the man from orbit. The manned vehicle or satellite that is placed into orbit is called the capsule, and the individual making the orbital flight is called the astronaut.

(2). A launch vehicle with a radio-inertial guidance system will be used to place the capsule into orbit. The launch will be from Cape Canaveral, Florida with launch azimuth slightly north of east (inclined 32.5 degrees to the equator) and nominal orbit insertion point approximately 410 nautical miles from Cape Canaveral. The planned orbit will have a period of 88 minutes and will be at an altitude of 105 ±5 nautical miles.

(3). Intitially, the orbital flights will each consist of three orbital cycles with a water landing west of Puerto Rico. In the event of an in-flight emergency, backup systems are provided in the capsule to permit the flight to continue until the next passage over the eastern United States. Emergency landings at the completion of one orbit can be made in the Atlantic off of Charleston, Sourth Carolina or near Bermuda. At the end of the second passage, the emergency landing area is in the Atlantic off of Charleston, South Carolina. If a malfunction occurs during the early launch phase, emergency procedures will permit a water landing off of Cape Canaveral. Controlled retro firing will be used to contain most of the abort impact areas near Bermuda or in the vicinity of the Canary Islands.

(4). To implement Project Mercury, a world wide network of 18 ground-based tracking and instrumentation sites has been established together with a control center and a computing and communications center. Eleven of these sites are equipped with long range tracking radars; these compose the tracking network. Sixteen sites have telemetry receiving and display equipment. Six of the sites are equipped to transmit command control signals to the capsule; these are known as command sites. Sixteen of the sites are equipped with capsule communications equipment that provides two-way voice contact with the astronaut. In addition, all of the sites are linked with the computing and control centers by a ground communications network. See figure 1-1 for the locations of the sites.

C. SITE FUNCTIONS

From orbit insertion until landing, the tracking and ground instrumentation systems will provide continuous prediction of the capsule location; they will monitor the status of the capsule and astronaut; and they will permit the command functions necessary for the mission. The functions of the tracking and ground instrumentation systems are completed when the capsule has landed and the best possible information on the landing point location has been supplied to a recovery team. Table 1-I lists the various sites and the functions of each.

D. SYSTEM FUNCTIONS

The function of the acquisition system is to supply pointing data (capsule azimuth and elevation) to the FPS-16 radar. Pointing data is made available to the automatic-tracking radar for initial acquisition of the capsule and to aid in quick re-acquisition if capsule tracking is lost during a pass over the site.

1-2. EQUIPMENT SUPPLIED

Table 1-II lists the equipment supplied for the acquisition system. A number of items of test equipment shown in this table are also used for other systems on the site. Such items are listed in the applicable manuals of the other systems as well as in this manual.

1-3. DESCRIPTION OF ACQUISITION SYSTEM

The acquisition system at White Sands consists primarily of an active acquisition aid, which is described in the following paragraphs.

TABLE 1-I. FUNCTIONS OF EACH SITE

	S-Band Radar Tracking	C-Band Radar Tracking	Telemetry & Capsule Communications	Command Control
Cape Canaveral, Florida	X	X	X	X
Grand Bahama Island	-	-	X	-
Grand Turk Island	-	-	X	-
Bermuda	X	X	X	X
Atlantic Ship	-	-	X	-
Grand Canary Island	X	-	X	-
Kano, Nigeria	-	-	X	-
Zanzibar	-	-	X	-
Indian Ocean Ship	-	-	X	-
Muchea, Australia	X	-	X	X
Woomera, Australia	-	X	X	-
Canton Island	-	-	X	-
Kauai Island, Hawaii	X	X	X	X
Point Arguello, California	X	X	X	X
Guaymas, Mexico	X	-	X	X
White Sands, New Mexico	-	X	-	-
Corpus Christi, Texas	X	-	X	-
Eglin, Florida	X	X	-	-

A. PHYSICAL DESCRIPTION

(1). ACTIVE ACQUISITION AID (Figures 1-2 through 1-10)

The active acquisition aid comprises eleven major units or assemblies; a control console, a receiver cabinet, a servo cabinet, an antenna and pedestal, two amplidynes, two diplexers, a triplexers, an RF housing, and a bore-sight antenna and transmitter.

TABLE 1-II. EQUIPMENT SUPPLIED

Equipment	Manufacturer	Model	Qty.	Instruction Book Inventory Number and Title
OPERATING EQUIPMENT				
Active Acquisition Aid, consisting of:	Cubic Corporation	-	1	MS-129, Instruction Manual for Active Acquisition Aid, (AGAVE)
Triplexer (multiplexer)			1	
Diplexer (multiplexer)			2	
RF Housing			1	
Amplidyne			2	
Receiver Cabinet			1	
Servo Cabinet			1	
Control Console			1	
Boresight Antenna and Transmitter			1	
Antenna and Pedestal, consisting of:				
Quad helix array			1	
Ground Plane			1	
Hybrid ring			4	
Pedestal			1	
Radar Display Panel	The Bendix Corporation, Bendix Radio Division	L654905-1	1	MS-118, Acquisition System Manual— Operation and Maintenance— White Sands, New Mexico
Antenna Drive Power Cutoff Switch and Warning Light	The Bendix Corporation, Bendix Radio Division	L653858-1	1	MS-118, Acquisition System Manual— Operation and Maintenance— White Sands, New Mexico
TEST EQUIPMENT				
Oscilloscope	Tektronix, Incorporated	545A	1	ME-202, Instruction Manual, Type 535A, Type 545A, Cathode Ray Oscilloscopes

TABLE 1-II. EQUIPMENT SUPPLIED (Cont.)

Equipment	Manufacturer	Model	Qty.	Instruction Book Inventory Number and Title
TEST EQUIPMENT (Cont.)				
Dual-Trace Calibrated Preamp	Tektronix, Incorporated	Type CA	1	ME-203, Instruction Manual, Type CA Plug-In Unit
Plug-In Preamplifier	Tektronix, Incorporated	Type L	1	ME-136, Instruction Manual, Type L Plug-In Unit
Viewing Hood	Tektronix, Incorporated	H510	1	ME-202, Instruction Manual, Type 535A, Type 545A, Cathode Ray Oscilloscopes (Accessories Section)
Oscilloscope Cart	Technibilt Corporation	OC-2 (Bendix Radio Part-A683940-1)	1	
Unit Regulated Power Supply	General Radio Company	1201-B	1	ME-211, Operating Instructions, Type 1201-B Unit Regulated Power Supply
Regulated Power Supply	Lambda Electronics Corporation	71	1	ME-138, Instruction Manual, Lambda Regulated Power Supply Model 71
DC Power Supply	John Fluke Manufacturing Company, Incorporated	407	1	ME-231, Model 407 DC Power Supply, Instruction Manual
Square Wave Generator	Tektronix, Incorporated	Type 105	1	ME-230, Instruction Manual, Square Wave Generator Type 105
Signal Generator	Boonton Radio Corporation	225-A	1	ME-188, Instruction Manual, Signal Generator Type 225-A
Sweep Generator	Telonic Industries, Incorporated	HN-3	1	ME-120, Operating Instruction Manual
HF Signal Generator	Hewlett-Packard Company	606-A	1	ME-189, Operating and Servicing Manual

TABLE 1-II. EQUIPMENT SUPPLIED (Cont.)

Equipment	Manufacturer	Model	Qty.	Instruction Book Inventory Number and Title
TEST EQUIPMENT (Cont.)				
Function Generator	Hewlett-Packard Company	202-A	1	ME-205, Operating and Servicing Manual
Transfer Oscillator	Hewlett-Packard Company	540-B	1	ME-232, Operating and Servicing Manual
Wide Range Oscillator	Hewlett-Packard Company	200 CD	1	ME-198, Operating and Servicing Manual
Unit Oscillator	General Radio Company	1209-BL	1	ME-212, Operating Instructions, Types 1209-B and BL Unit Oscillators
Universal EPUT and Timer	Beckman Instruments, Incorporated	7370	1	ME-196, Instruction Manual, Model 7370 Universal EPUT and Timer
Frequency Converter	Beckman Instruments, Incorporated	7570 through 7573	1	ME-197, Instruction Manual, Model 7570 Series Frequency Conversion Equipment
Field Strength Meter	Empire Devices Products Corporation	NF-105 (Bendix Part No. A683351)	1	ME-192, Instruction Manual, Noise and Field Intensity Meter
Microwave Power Meter	Hewlett-Packard Company	430C	1	ME-233, Operating and Servicing Manual
Potentiometric DC Voltmeter	John Fluke Manufacturing Company, Incorporated	801	1	ME-118, Instruction Manual, Model 801 Potentiometric DC Voltmeter
Vacuum Tube Voltmeter	Hewlett-Packard Company	410B	1	ME-190, Operating and Servicing Manual
Vacuum Tube Voltmeter	Hewlett-Packard Company	400D	1	ME-191, Operating and Servicing Manual, 400D/H/L Vacuum Tube Voltmeter

TABLE 1-II. EQUIPMENT SUPPLIED (Cont.)

Equipment	Manufacturer	Model	Qty.	Instruction Book Inventory Number and Title
TEST EQUIPMENT (Cont.)				
Volt-Ohm-Milliammeter	Triplett Electrical Instrument Company	630-PL	1	ME-193, Instruction Manual, Model 630-PL Volt-Ohm-Milliammeter
Noise and Distortion Analyzer	Hewlett-Packard Company	330B	1	ME-194, Operating and Servicing Manual, 330B/C/D Noise and Distortion Analyzer
RF Detector	Telonic Industries, Incorporated	XD-3	2	ME-135, Instruction Manual
Tube Analyzer	Triplett Electrical Instrument Company	3444	1	ME-199, Instruction Manual, Model 3444 Tube Analyzer
Variac	General Radio Company	W10MT	1	ME-246, Operating Instructions, W10 Variac
Attenuator Pad	Telonic Industries, Incorporated	TGC-50	2	-
Miscellaneous Cables and Accessories	-	-	-	-

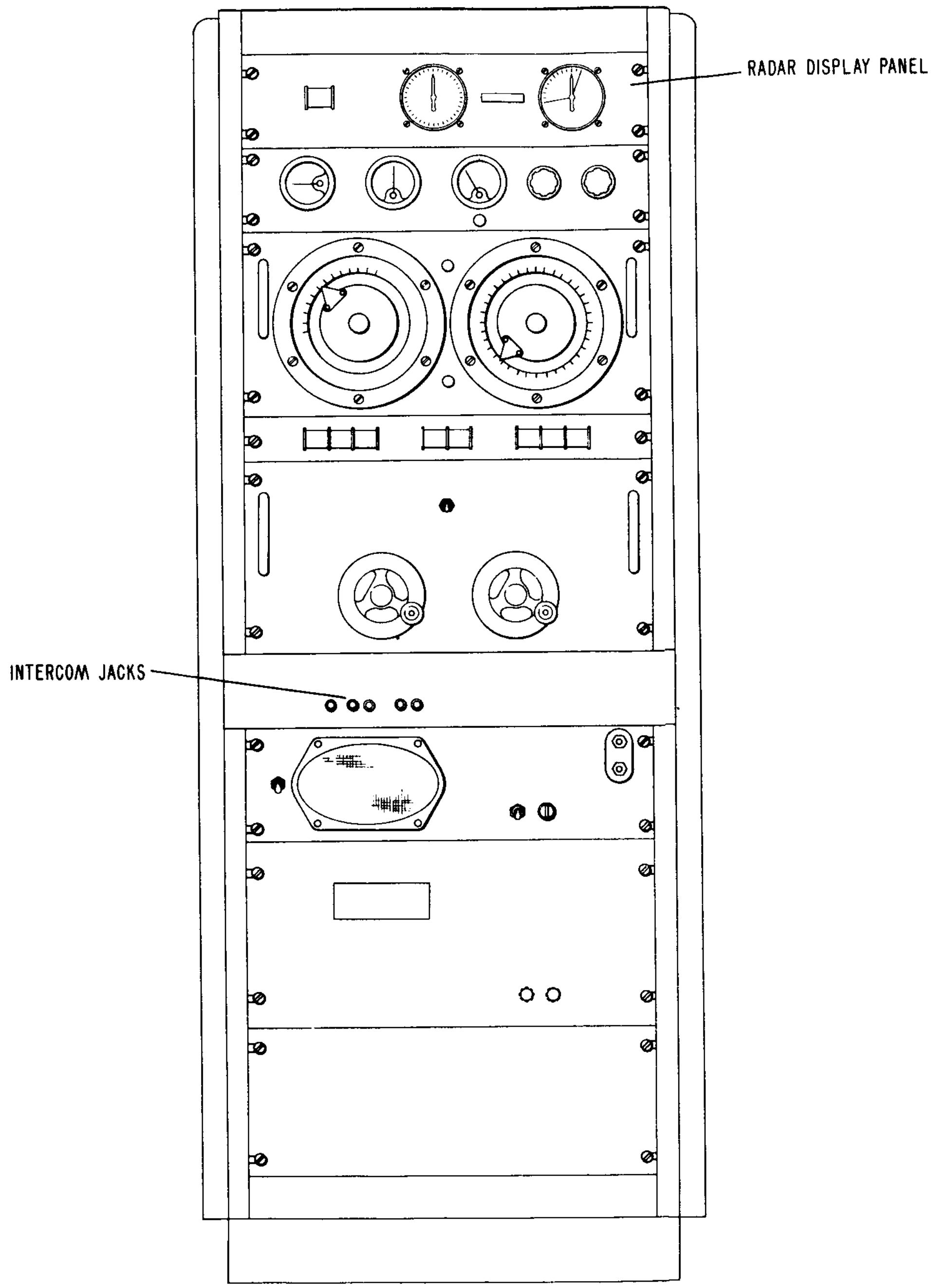


Figure 1-2. Active Acquisition Aid Control Console

(a). The active acquisition aid control console (figure 1-2) consists of a rack, 59-5/8 inches high, 23-9/16 inches wide, and 22 inches deep, on which are mounted several panels. On these panels are controls, indicators, and switches for the operation of the active acquisition aid. The topmost panel is the radar display panel. On this panel there are two synchro receivers that display azimuth and elevation data from the FPS-16, an indicator labeled "VALID TRACK," two relays, and a resistor. For a description of the other panels on the control console, refer to the active acquisition aid equipment manual, listed in table 1-II.

(b). The receiver cabinet contains the circuits of the active acquisition aid which develop the error signals used to position the antenna for tracking. The receiver cabinet is 23-9/16 inches wide, 22 inches deep, and 77 inches high. It is bolted to the servo cabinet. (See figure 1-3.)

(c). The servo cabinet (figure 1-3) houses components of the servo system which positions the antenna in azimuth and elevation. Its overall physical dimensions are the same as those of the receiver cabinet, to which it is bolted.

(d). The active acquisition aid antenna and pedestal (figure 1-4) includes a quad helix array, a ground plane, four hybrid rings, an antenna drive power cutoff switch and warning light, and the pedestal itself. The antenna drive power cutoff switch and warning light consists of a double-pole, single-throw switch and a red warning light mounted on a 6-inch by 12-3/4-inch frame. (See figure 1-5.)

(e). For physical descriptions of the amplidynes, diplexers, triplexer, RF housing, and boresight antenna and transmitter (figures 1-6 through 1-10) and for complete physical descriptions of the control console, receiver cabinet, servo cabinet, and antenna and pedestal, refer to the applicable equipment manual.

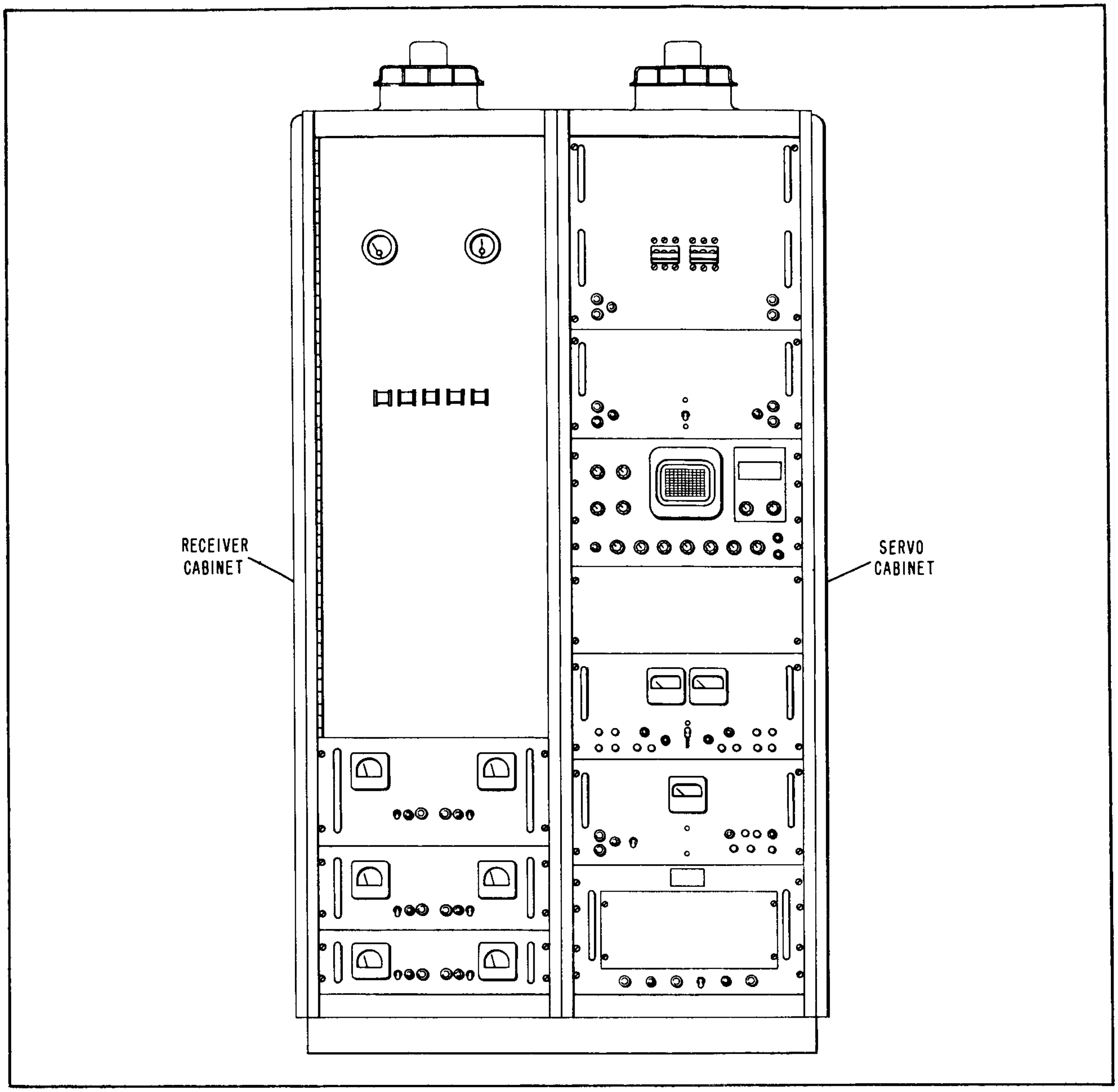


Figure 1-3. Active Acquisition Aid Receiver Cabinet and Servo Cabinet

B. FUNCTIONAL DESCRIPTION

(1). GENERAL

(a). The function of the acquisition system at White Sands is to supply the best (most accurate) data available on the azimuth and elevation of the Mercury capsule to the FPS-16 radar on the site. Once the active acquisition aid has acquired the capsule and is

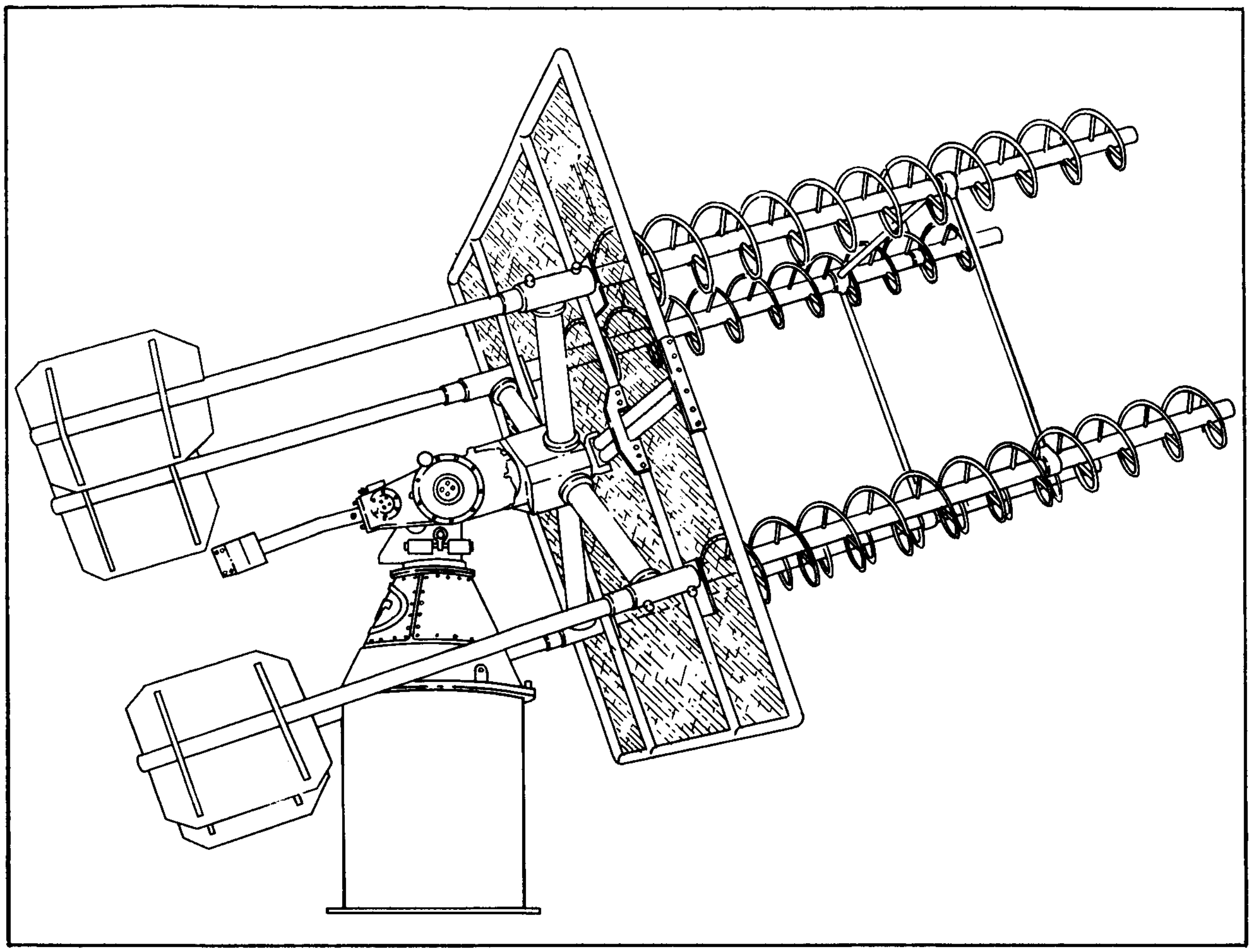


Figure 1-4. Active Acquisition Aid Antenna and Pedestal

tracking it automatically or manually, its information on capsule azimuth and elevation is available for use by the FPS-16 radar.

(b). Figure 1-11 is a simplified block diagram of the acquisition system. The acquisition bus is illustrated by a heavy line. Azimuth and elevation data on the lens from the active acquisition aid goes directly to the FPS-16 radar, where it is used by the radar as an aid in acquiring the capsule. Display data from the radar is supplied to the active acquisition aid control console where it is displayed on the radar display panel. In addition to position and display data, operating mode indications are supplied from the active acquisition aid to the FPS-16 radar and vice versa. The paths of the operating mode indication circuits are not shown on figure 1-11.

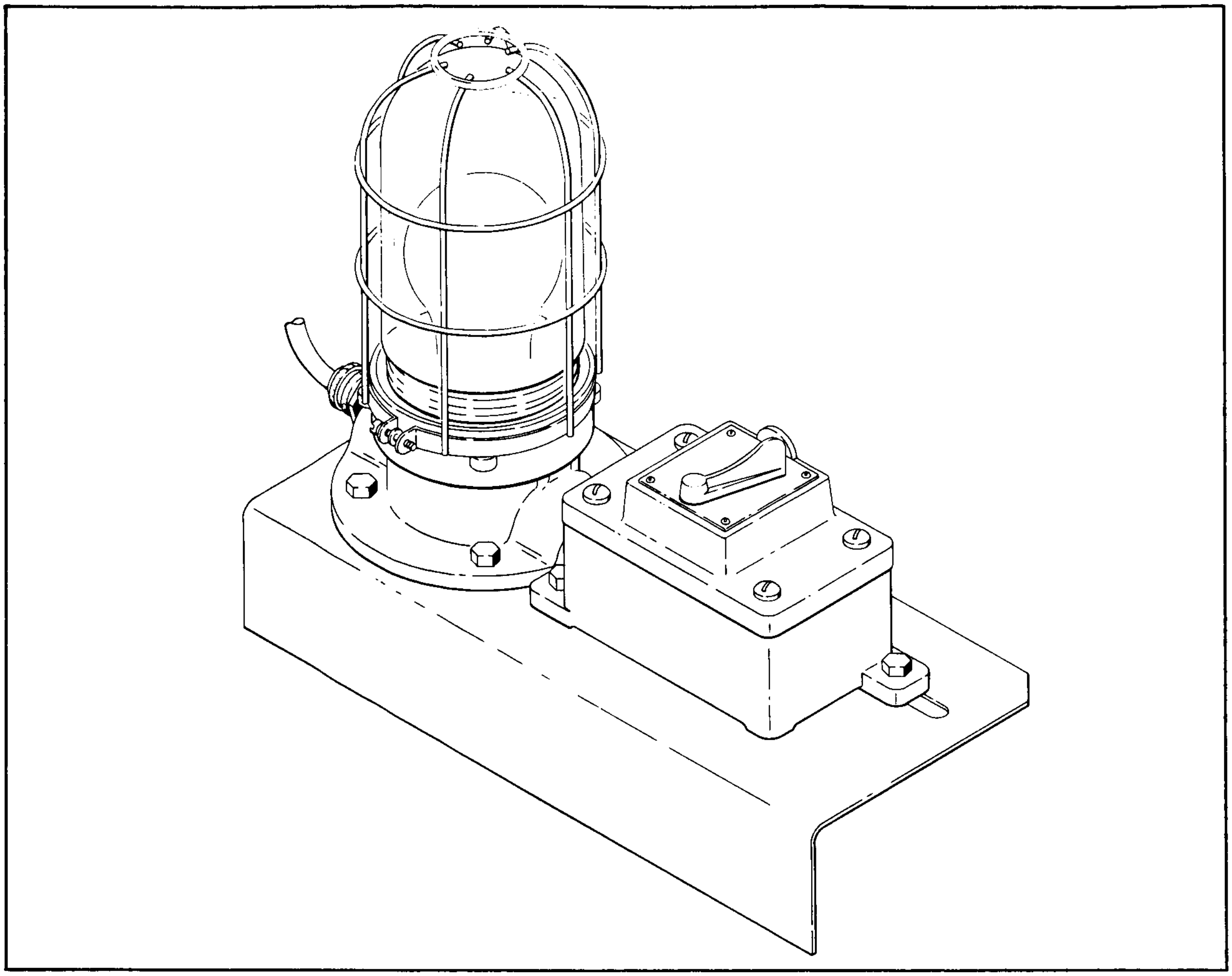


Figure 1-5. Antenna Drive Power Cutoff Switch and Warning Light

(2). ACTIVE ACQUISITION AID

(a). The active acquisition aid is an automatic angle-tracking device which provides acquisition data for use by the FPS-16 radar. It tracks the capsule in azimuth and elevation (but not in range) by means of the telemetry signals transmitted from the capsule, and puts out azimuth and elevation position data.

(b). The salient characteristics of the active acquisition aid are as follows.

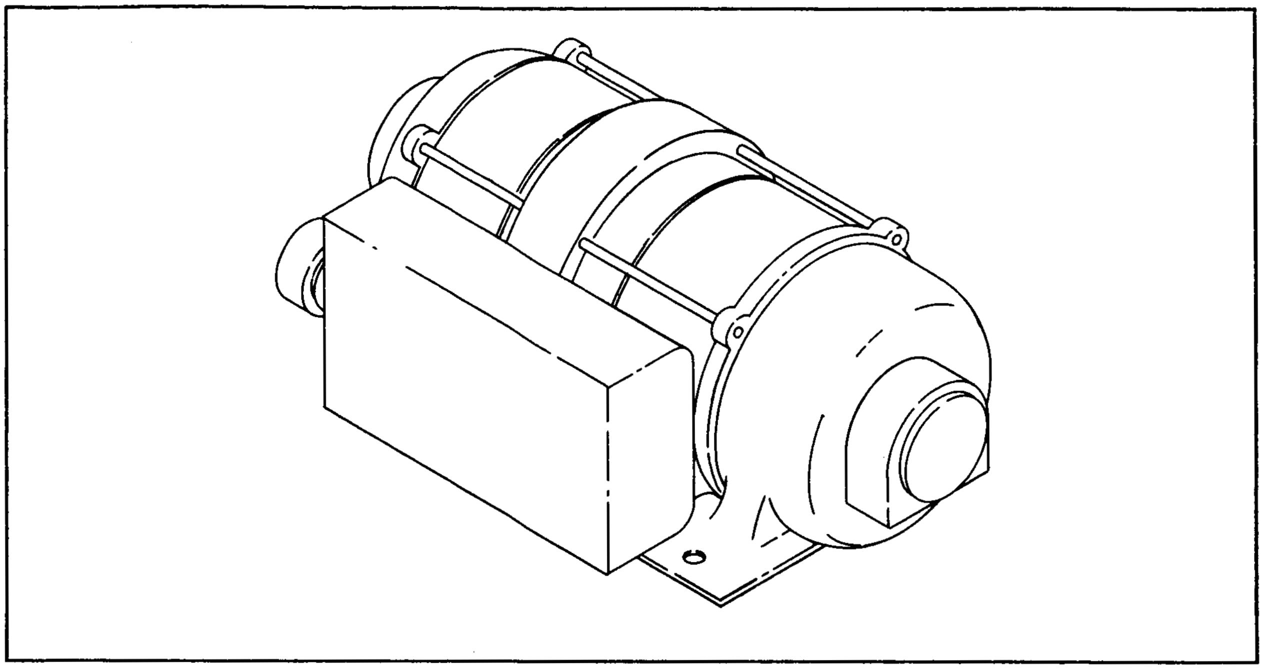


Figure 1-6. Active Acquisition Aid Amplidyne

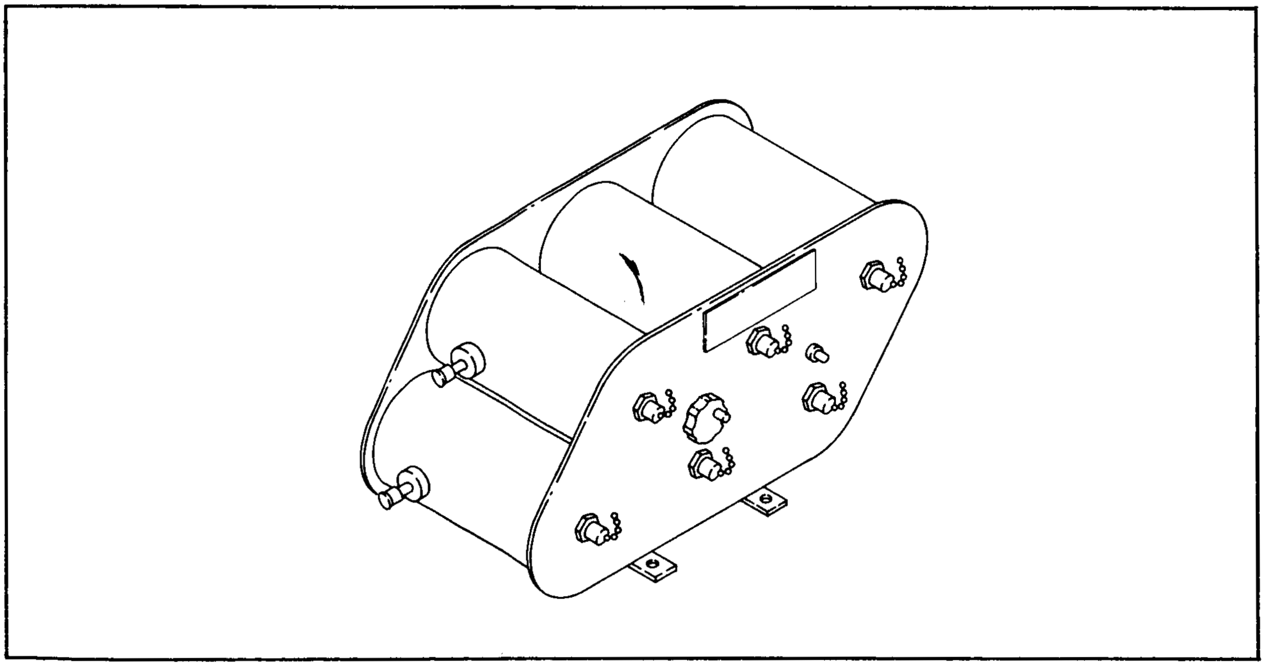


Figure 1-7. Active Acquisition Aid Diplexer (Multiplexer)

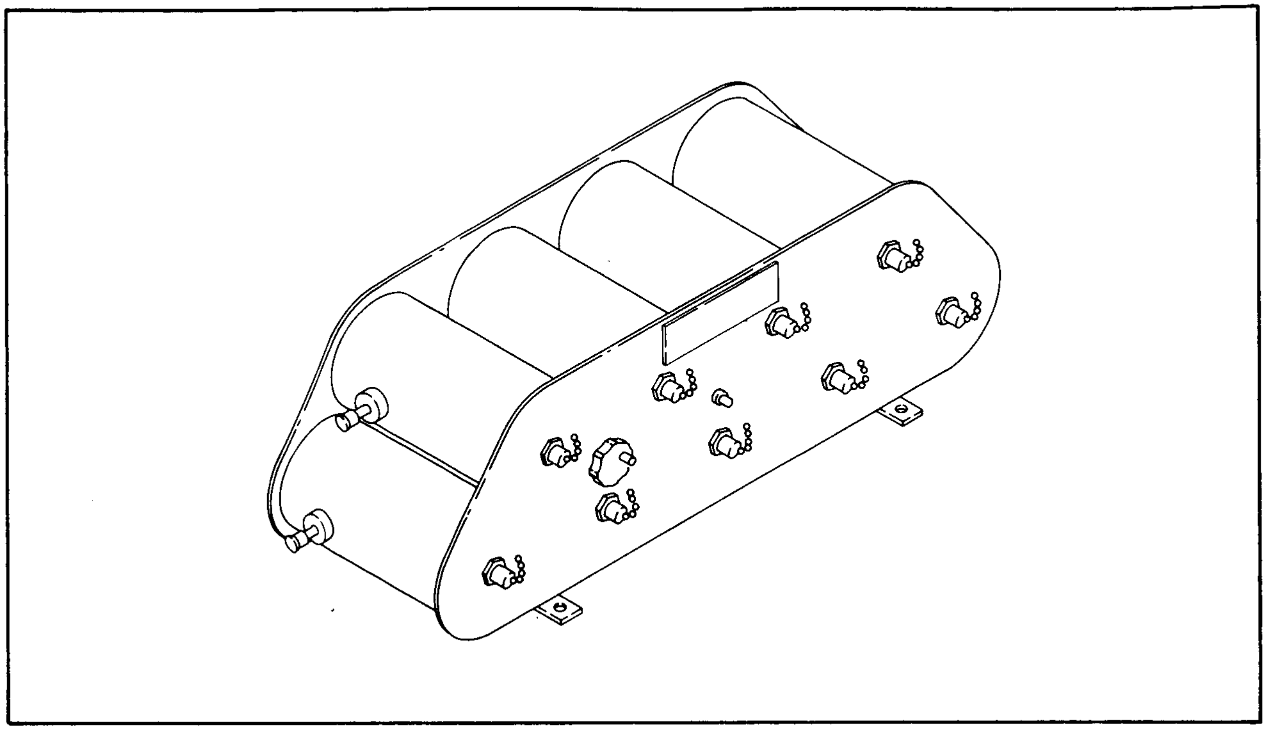


Figure 1-8. Active Acquisition Aid Triplexer (Multiplexer)

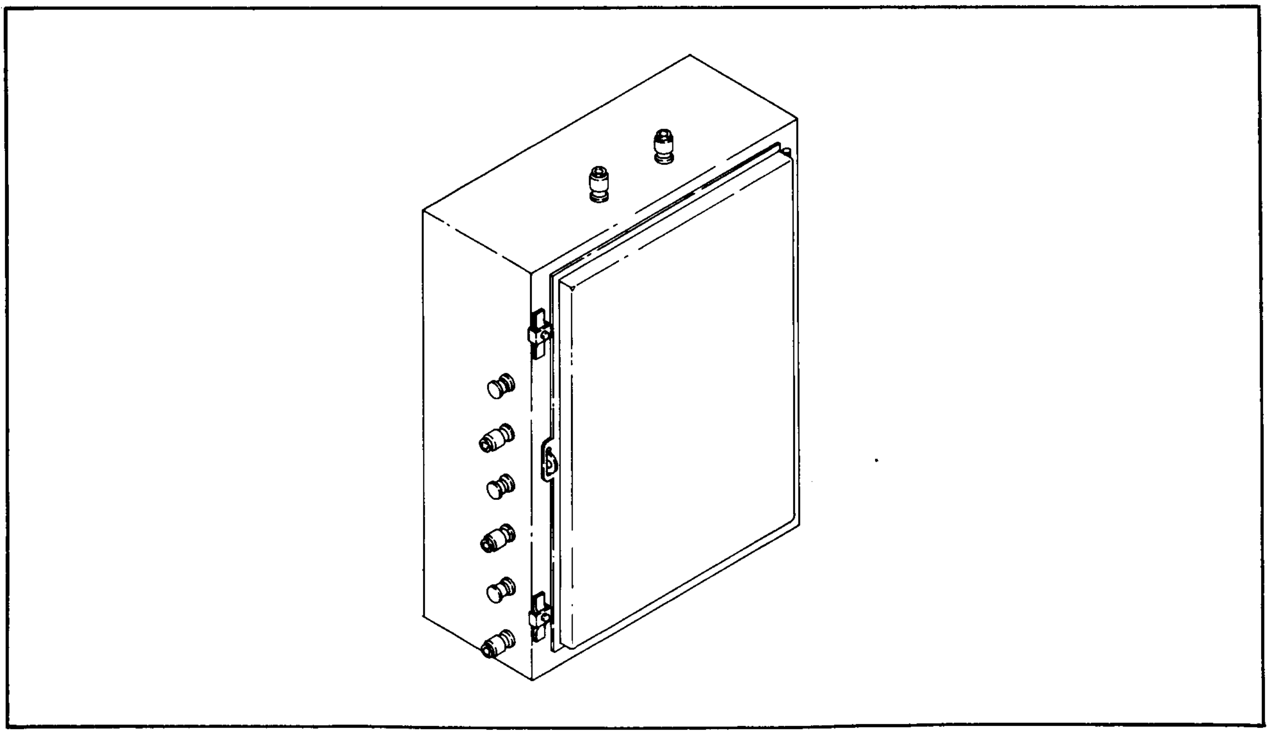


Figure 1-9. Active Acquisition Aid RF Housing

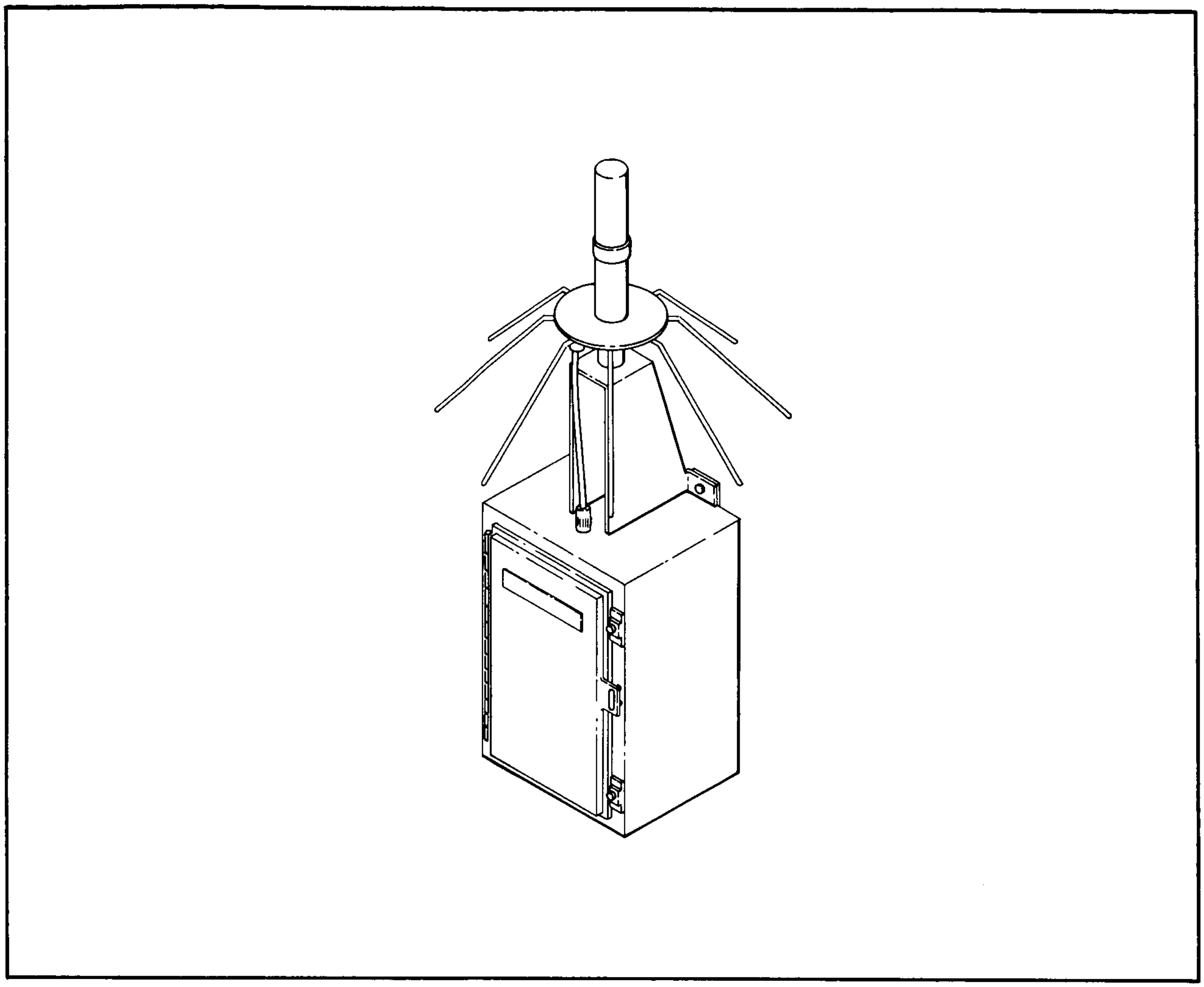


Figure 1-10. Active Acquisition Aid Boresight Antenna and Transmitter

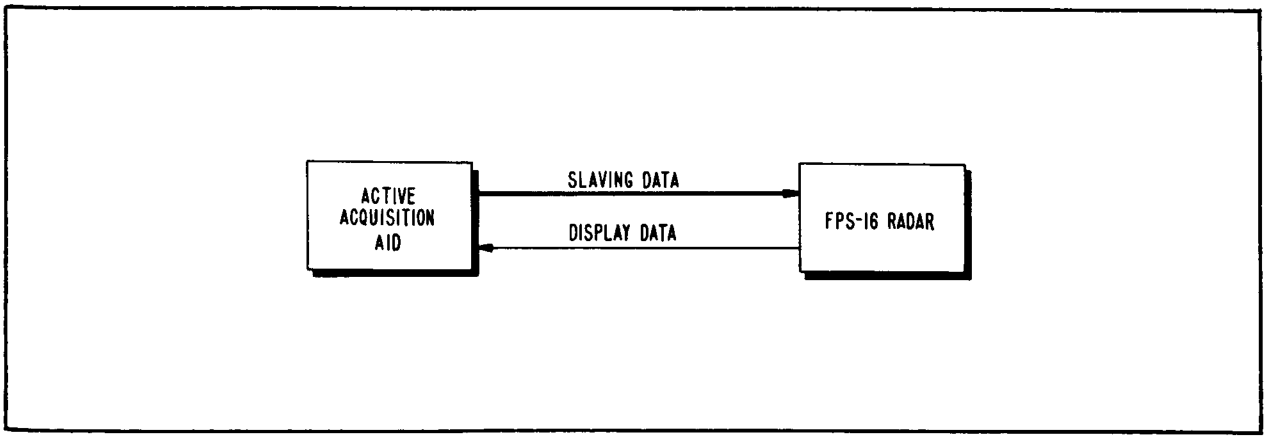


Figure 1-11. Acquisition System, Simplified Block Diagram

Operating modes: automatic, manual, slaved (not used)

Operating frequency: either one of any two, preset frequencies in the range 225 to 260 MC.

Tracking accuracy (at 10° per second tracking rate)

Azimuth: 0.5°

Elevation: 0.5° at angles greater than 15°

1.0° at angles between 10° and 15°

Antenna

Type of array: quad helix

Polarization: circular, right-hand sense

Elevation limits: minus 10° to plus 10°

Azimuth limit: 540°

Beamwidth: 20° at 3-db points.

(c). Azimuth and elevation synchro display data from the FPS-16 radar comes into the active acquisition aid control console and is displayed on a pair of synchro receivers on the radar display panel. An FPS-16 "VALID TRACK" operating mode indication is also displayed on the radar display panel.

(d). The antenna drive power cutoff switch and warning light is mounted on the active acquisition aid antenna tower. When open, it disconnects antenna drive motor power. The warning light is lit whenever the switch is closed. (See section II for the location of the cutoff switch and warning light.)

(e). For a complete functional description of the active acquisition aid, refer to the equipment manual.

1-4. SITE IMPLEMENTATION

This paragraph deals with the allocation, location, and housing of equipment for the acquisition system at White Sands.

A. EQUIPMENT ALLOCATION

The equipment which makes up the acquisition system at White Sands is listed in table 1-II.

B. SITE DESCRIPTION

(1). SITE LAYOUT

Acquisition equipment at White Sands is in the active acquisition aid building (also known as the camera building), on the active acquisition aid antenna tower, in the amplidyne building, and on a boresight tower (see figure 1-12). The amplidyne building is next to the active acquisition aid building, the active acquisition aid antenna is north of the building, and the boresight tower is northeast of the building.

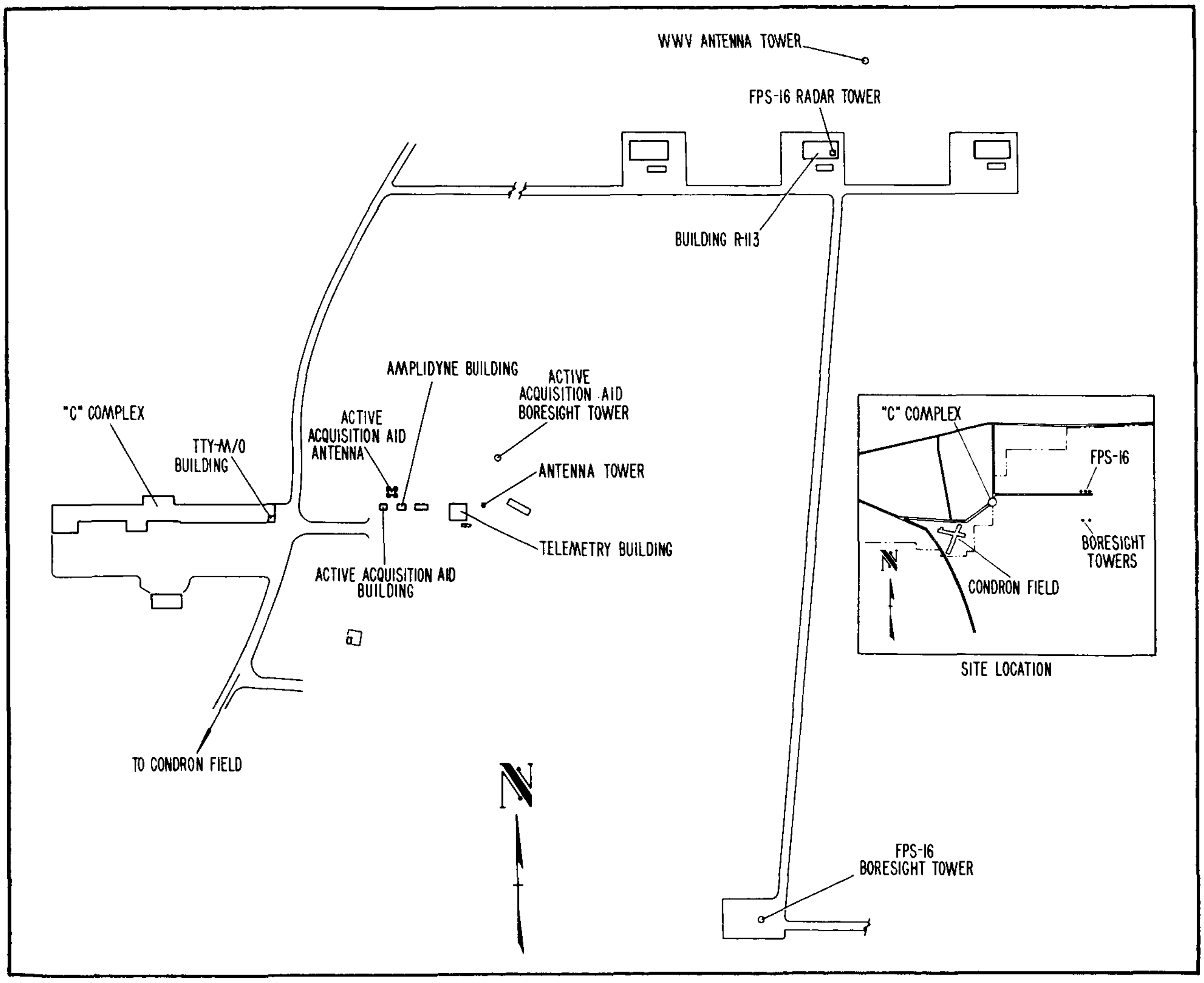


Figure 1-12. Site Layout, White Sands, New Mexico

(2). EQUIPMENT LOCATION

(a). ACTIVE ACQUISITION AID

The active acquisition aid control console and receiver and servo cabinets are in the active acquisition aid building as shown in figure 1-13. The amplidynes are in the amplidyne building. The RF housing, the diplexers, and the triplexer are mounted on the antenna tower. The boresight antenna is on the boresight tower, and the boresight transmitter is at the base of the tower.

(b). FPS-16 RADAR

The FPS-16 radar, which is connected to the acquisition system, is located in its own building, northeast of the active acquisition aid building (see figure 1-12).

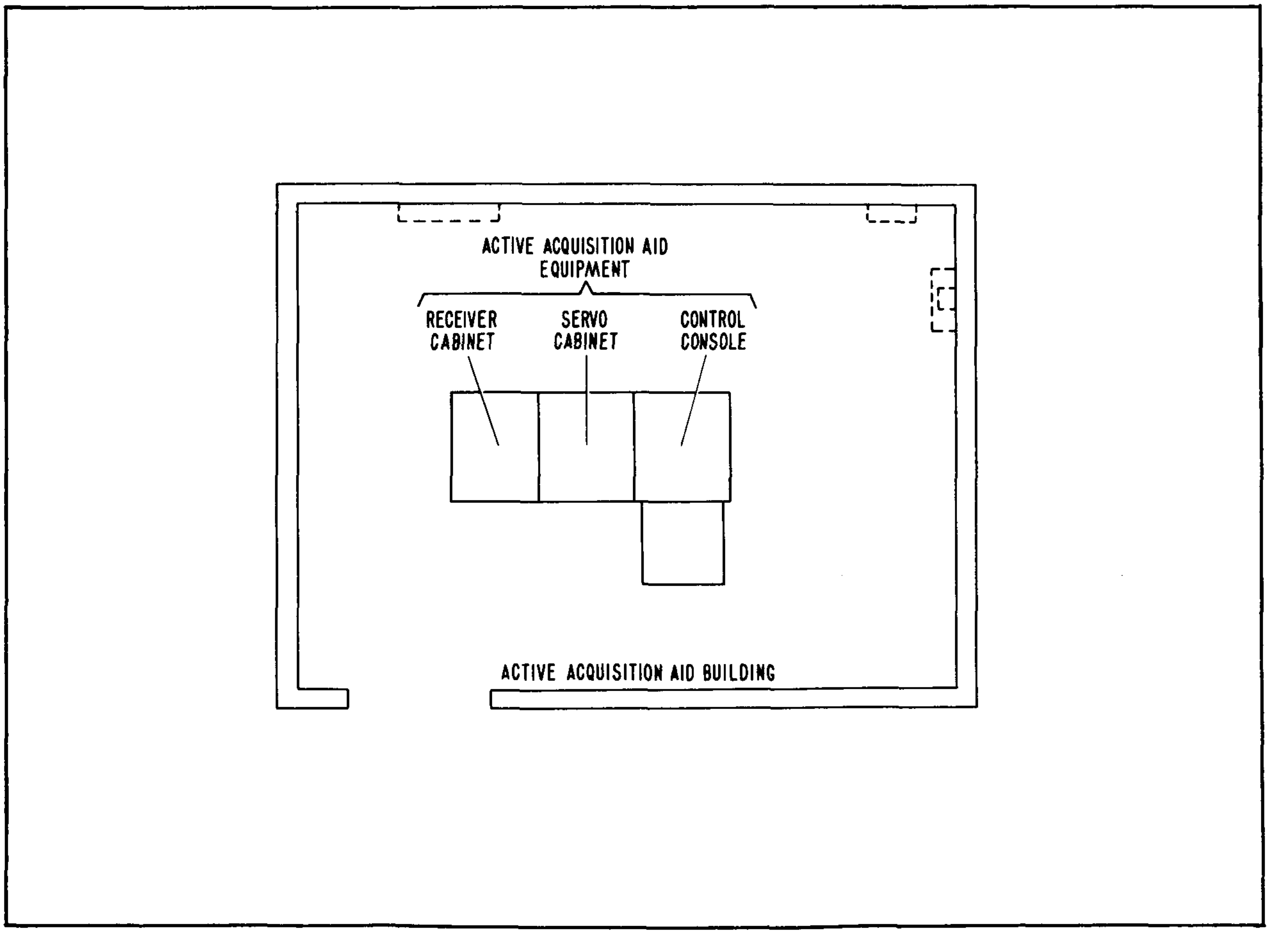


Figure 1-13. Acquisition System Equipment Layout, Active Acquisition Aid Building

SECTION II
INSTALLATION

2-1. GENERAL

This section comprises instructions and other information for installing the equipment which makes up the acquisition system. Equipment installation on building floors and on antenna towers are covered in separate paragraphs.

2-2. EQUIPMENT INSTALLATION

A. FLOOR MOUNTED EQUIPMENT

(1). CONSOLE AND CABINETS

The console and equipment cabinets in the acquisition system comprise two units. One of these is the active acquisition aid control console. The other unit is made up of the active acquisition aid receiver and servo cabinets bolted together and installed as a single unit. Figure 1-13 shows the approximate location of the acquisition system equipment in the site building. Figures 2-1 and 2-2 give the outline dimensions of the console and cabinet units. The console and cabinet units are secured to the floor by anchor bolts. Mounting hole locations and details of the anchor bolt installations are shown on figure 2-3. A complete listing of the hardware required for mounting the units is given in table 2-I.

(2). AMPLIDYNES

The active acquisition aid amplidynes are installed in a separate building shown on figure 1-12. Each amplidyne is bolted to a steel channel, which is secured to the concrete floor with anchor bolts. See figure 2-4 for details of the installation, and refer to table 2-I for the hardware required.

B. EQUIPMENT ON TOWERS

(1). ANTENNA AND PEDESTAL

The active acquisition aid antenna and pedestal are installed on a tower constructed for that purpose; tower location is shown in figure 1-12. For instructions on the installation of the active acquisition aid antenna and pedestal, refer to the applicable equipment manual, listed in table 1-II.

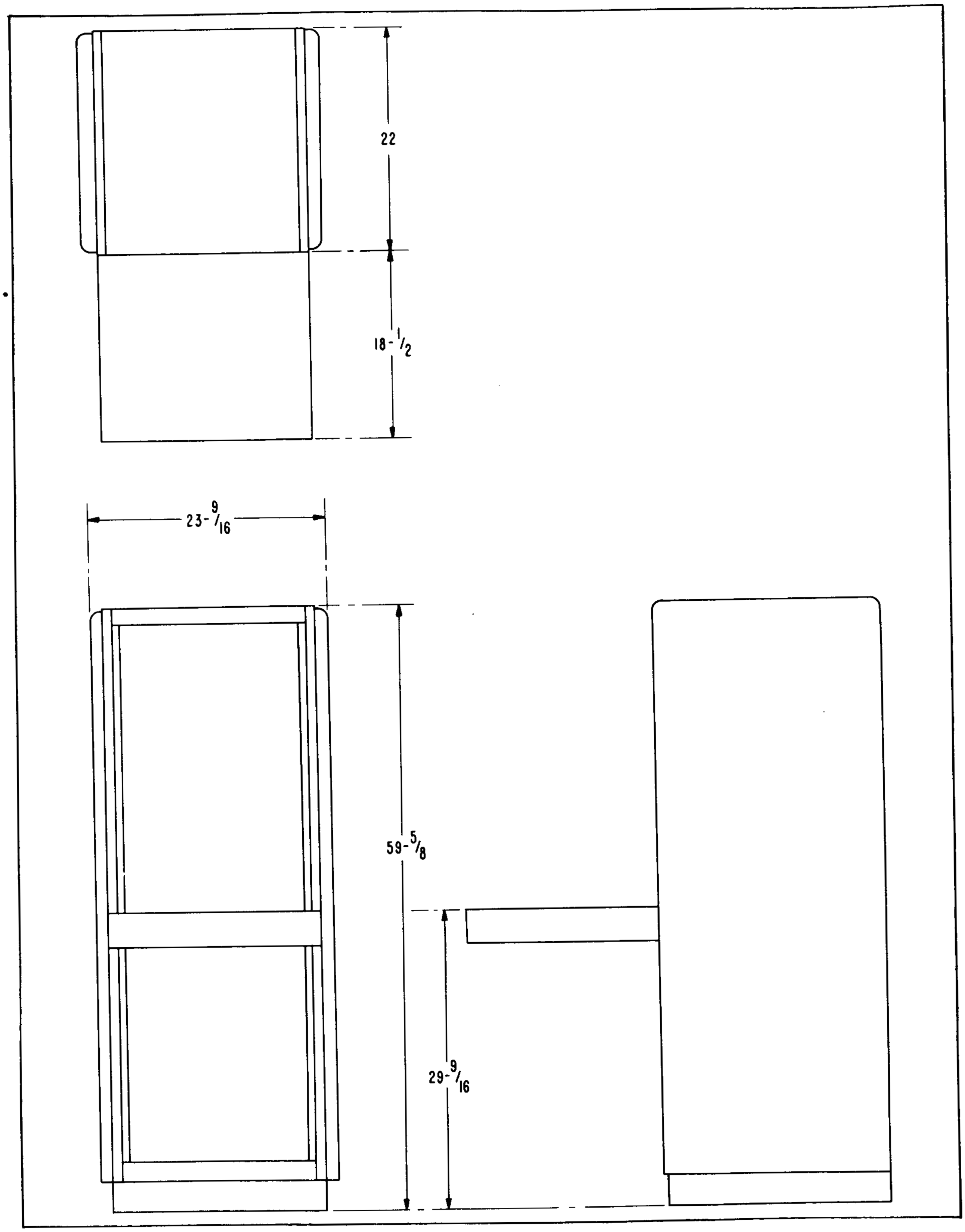


Figure 2-1. Active Acquisition Aid Control Console Outline Dimensions

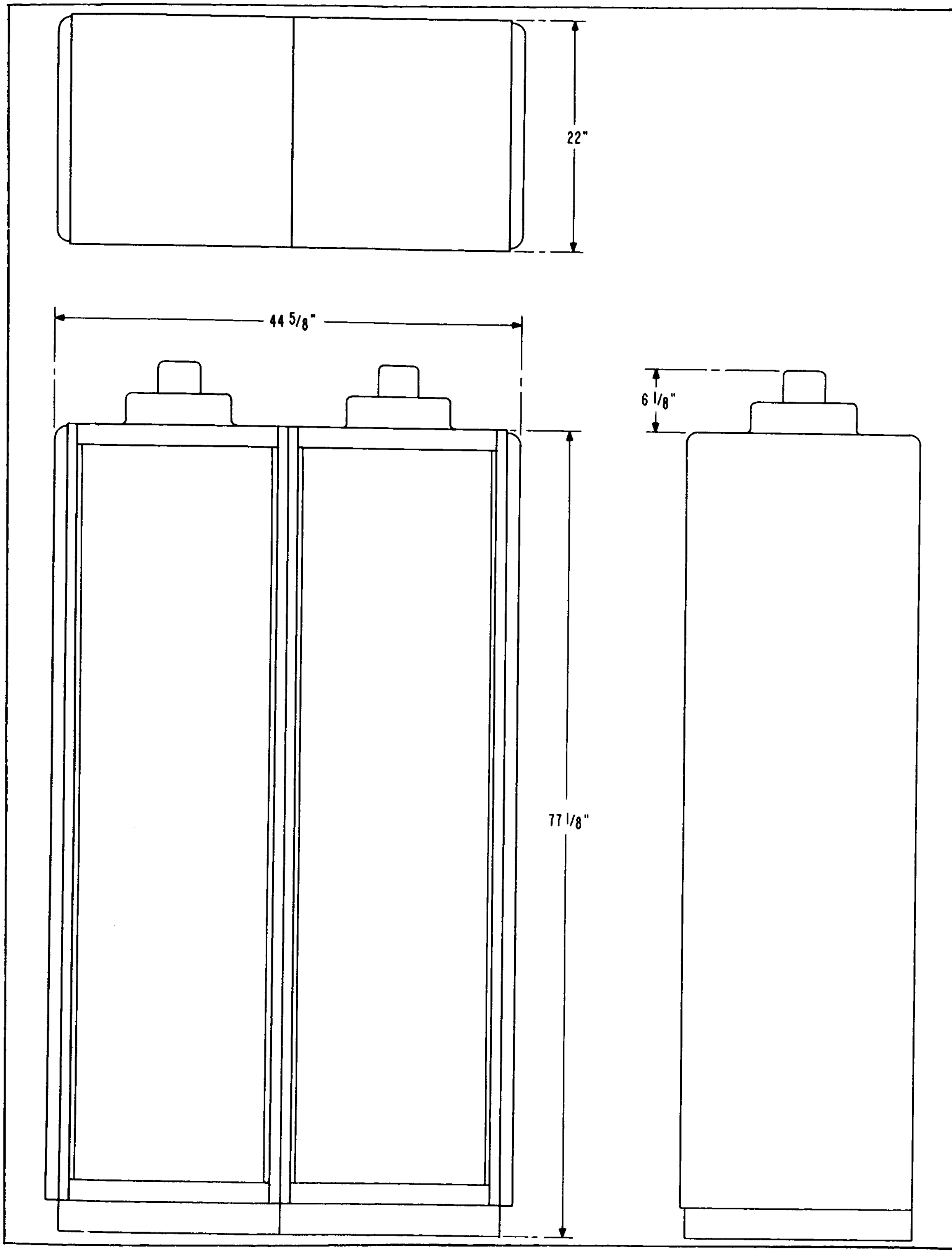


Figure 2-2. Active Acquisition Aid Receiver and Servo Cabinet Outline Dimensions

TABLE 2-I. EQUIPMENT MOUNTING HARDWARE

Hardware Name and Description	Part Number	Qty.
ACTIVE ACQUISITION AID CONTROL CONSOLE [See figure 2-3(C)]		
Anchor bolt, 5/16" lead insert	A68322-1	4
Bolt, 5/16" - 18NC, 1" long	HK936S16-2018	4
Flat washer, 5/16"	HK779S20-A	4
Lock washer, 5/16"	HK779G20-E	4
ACTIVE ACQUISITION AID RECEIVER AND SERVO CABINETS [See figure 2-3(A)]		
Same as active acquisition aid control console.		
ACTIVE ACQUISITION AID AZIMUTH AMPLIDYNE [See figures 2-3(B), 2-3(D), 2-4)]		
Mounting channel	N683369-1	1
Anchor bolt, 5/16" lead insert	A683322-1	4
Bolt, 5/16" - 18NC, 4-1/4" long	HK936S68-2018	4
Bolt, 5/16" - 18NC, 1-1/4" long	HK936S20-2018	8
Flat washer, 5/16"	HK779S20-A	12
Lock washer, 5/16"	HK779G20-E	12
ACTIVE ACQUISITION AID ELEVATION AMPLIDYNE		
Same as active acquisition aid azimuth amplidyne.		
ACTIVE ACQUISITION AID TRIPLEXER (See figure 2-5)		
Support bracket	N653929-1	1
Bolt, 1/2" - 13NC, 1-1/4" long	HK936S20-3212	4
Nut, 1/2" - 13NC	HK775S32-13	4
Flat washer, 1/2"	HK779S32-A	4
Lock washer, 1/2"	HK799G32-M	4
Bolt, 3/8" - 16NC, 1-1/4" long	HK936S20-2416	4
Nut, 3/8" - 16NC	HK775S24-16	4
Flat washer, 3/8"	HK779S24-A	4
Lock washer, 3/8"	HK779G24-M	4

TABLE 2-I. EQUIPMENT MOUNTING HARDWARE (Cont.)

Hardware Name and Description	Part Number	Qty.
ACTIVE ACQUISITION AID DIPLEXERS (See figure 2-5.)		
Beam support	L683396-1	1
Clip angle	C683397-1	4
Mounting plate	N683395-1	1
Bolt, 3/8" - 16NC, 1-1/4" long	HK936S20-2416	29
Nut, 3/8" - 16NC	HK775S24-16	29
Flat washer, 3/8"	HK779S24-A	29
Lock washer, 3/8"	HK779G24-M	29
ACTIVE ACQUISITION AID RF HOUSING (See figure 2-5.)		
Mounting bracket	SK-1000-402	1
Bolt, 3/8" - 16NC, 1-1/2" long	HK936S24-2416	3
Bolt, 3/8" - 16NC, 1-1/4" long	HK936S20-2416	6
Nut, 3/8" - 16NC	HK775S24-16	9
Flat washer, 3/8"	HK779S24-A	9
Lock washer, 3/8"	HK779G24-M	9
ANTENNA DRIVE POWER CUTOFF SWITCH AND WARNING LIGHT (See figure 2-5.)		
Binder head screw, 10-32, 7/8" long	HK950S28-1032	3
Hex nut, 10-32	HK775S10-32	3
Lock washer, No. 10	HK799G10-M	3
ACTIVE ACQUISITION AID BORESIGHT TRANSMITTER (See figure 2-6.)		
Mounting channel	N689950-1	1
Bolt, 1/4" - 20NC, 3/4" long	HK936S12-1620	6
Flat washer, 1/4"	HK779S16-A	6
Lock washer, 1/4"	HK799G16-H	6
Bolt, 3/8" - 16NC, 7/8" long	HK936S14-2416	4
Nut, 3/8" - 16NC	HK775S24-16	4
Flat washer, 3/8"	HK779S24-A	4
Lock washer, 3/8"	HK799G24-H	4

TABLE 2-I. EQUIPMENT MOUNTING HARDWARE (Cont.)

Hardware Name and Description	Part Number	Qty.
ACTIVE ACQUISITION AID BORESIGHT ANTENNA (See figure 2-6.)		
Antenna Support	653792-1	1
Mounting plate	653751-2	1
Clamp	689834-1	2
Bolt, 3/8" - 16NC, 1" long	HK936S16-2416	6
Nut, 3/8" - 16NC	HK775S24-16	4
Lock washer, 3/8"	HK799G24-M	10

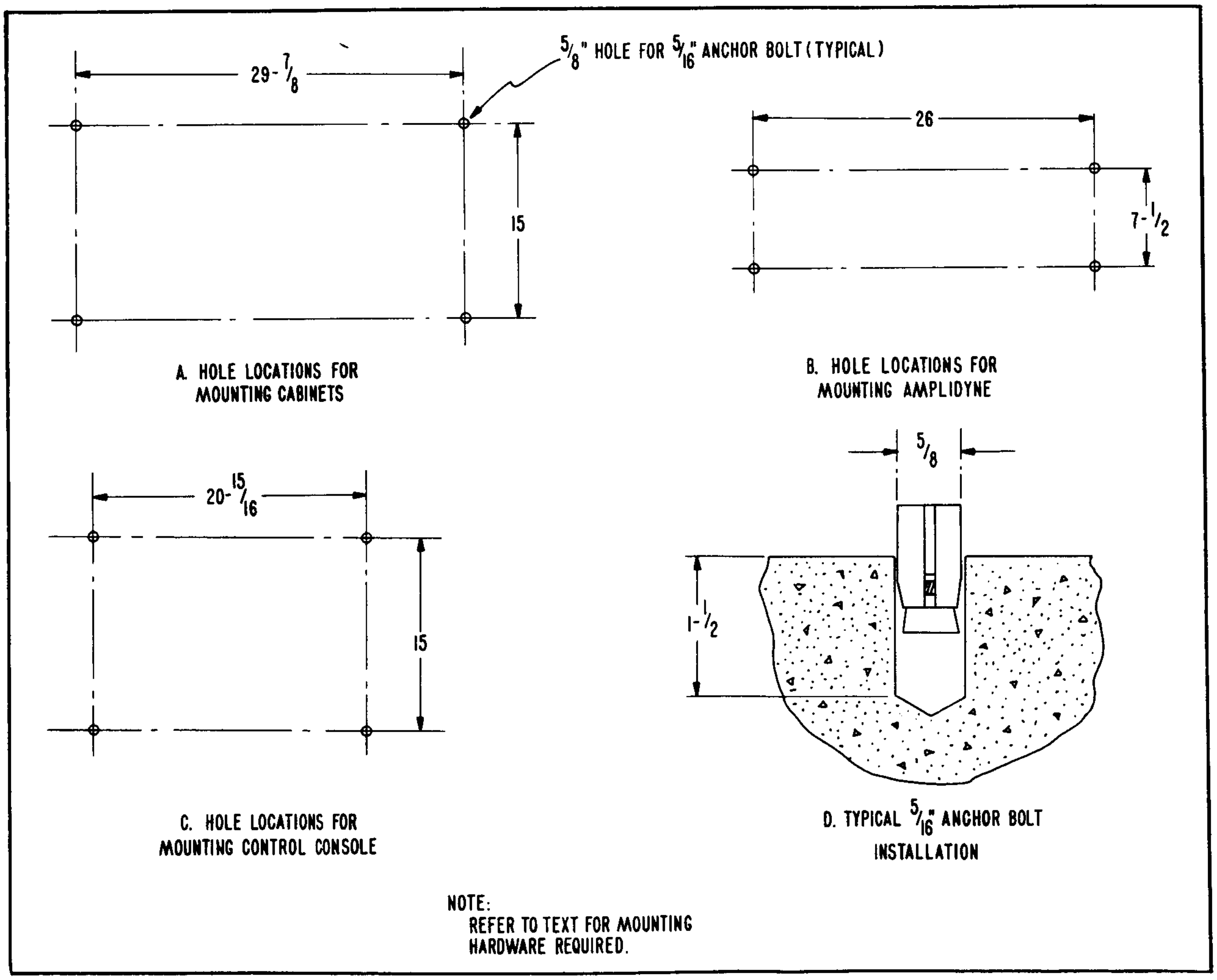


Figure 2-3. Mounting Hole Locations

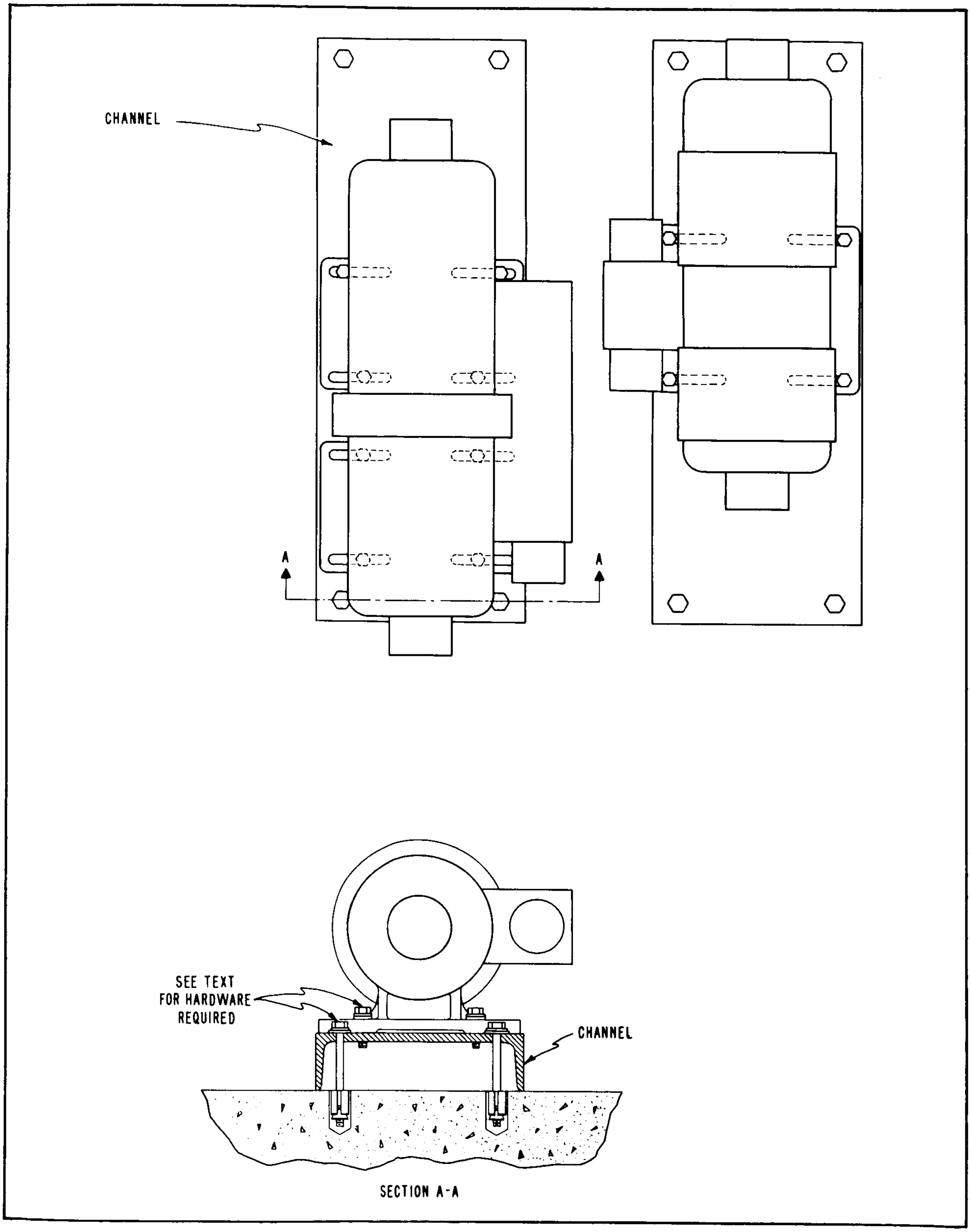


Figure 2-4. Amplidyne Installation

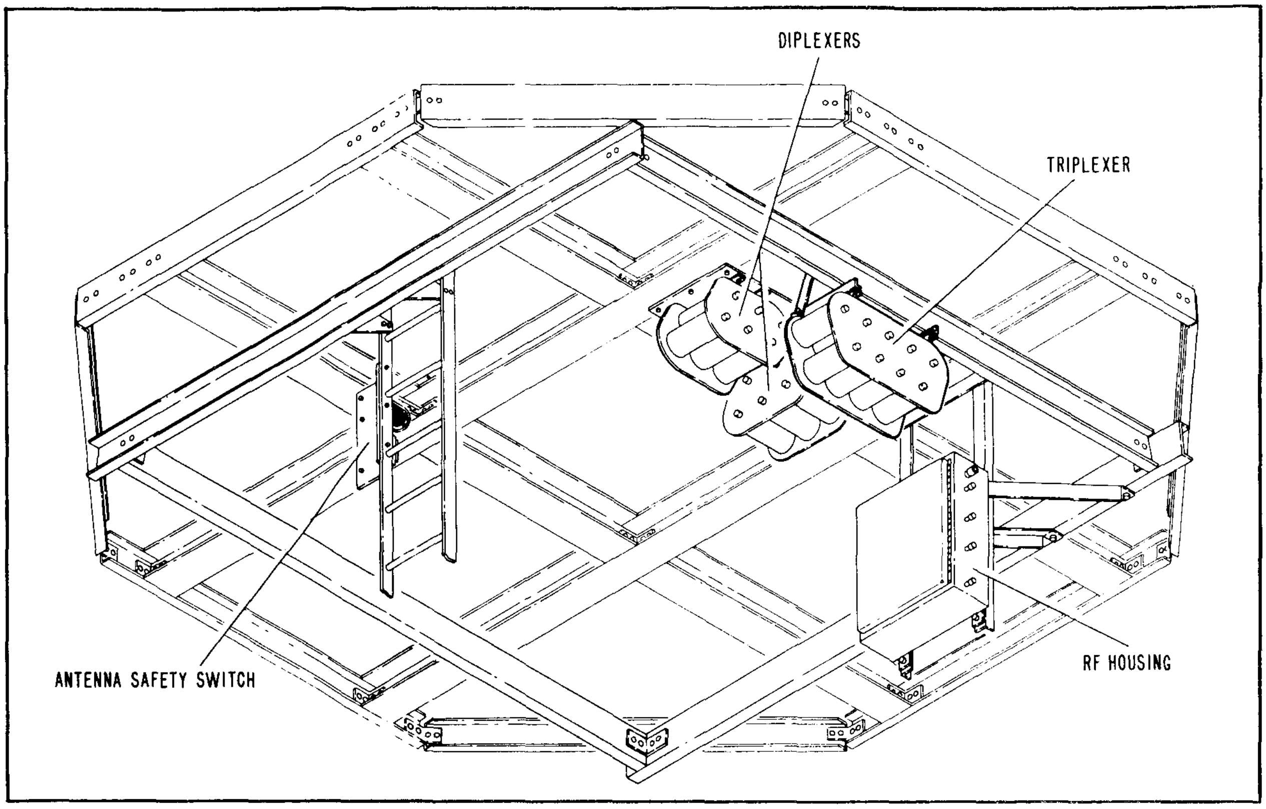


Figure 2-5. Active Acquisition Aid RF Equipment Installation

(2). RF HOUSING

The active acquisition aid RF housing is installed on the underside of the antenna tower platform in the location shown on figure 2-5. The unit is supported by a special bracket which is fastened to the tower platform. Refer to table 2-I for the installation hardware required.

(3). MULTIPLEXERS

The active acquisition aid multiplexers (triplexer and two diplexers) are mounted underneath the antenna tower platform. The triplexer is fastened to a bracket, and the two diplexers are fastened to a common mounting plate. See figure 2-5 for the location of these components, and refer to table 2-I for the hardware required for installation.

(4). ANTENNA DRIVE POWER CUTOFF SWITCH AND WARNING LIGHT

The antenna drive power cutoff switch and warning light is mounted near the top of one of the ladders leading to the top of the antenna platform. The required hardware is listed in table 2-I. See figure 2-5.

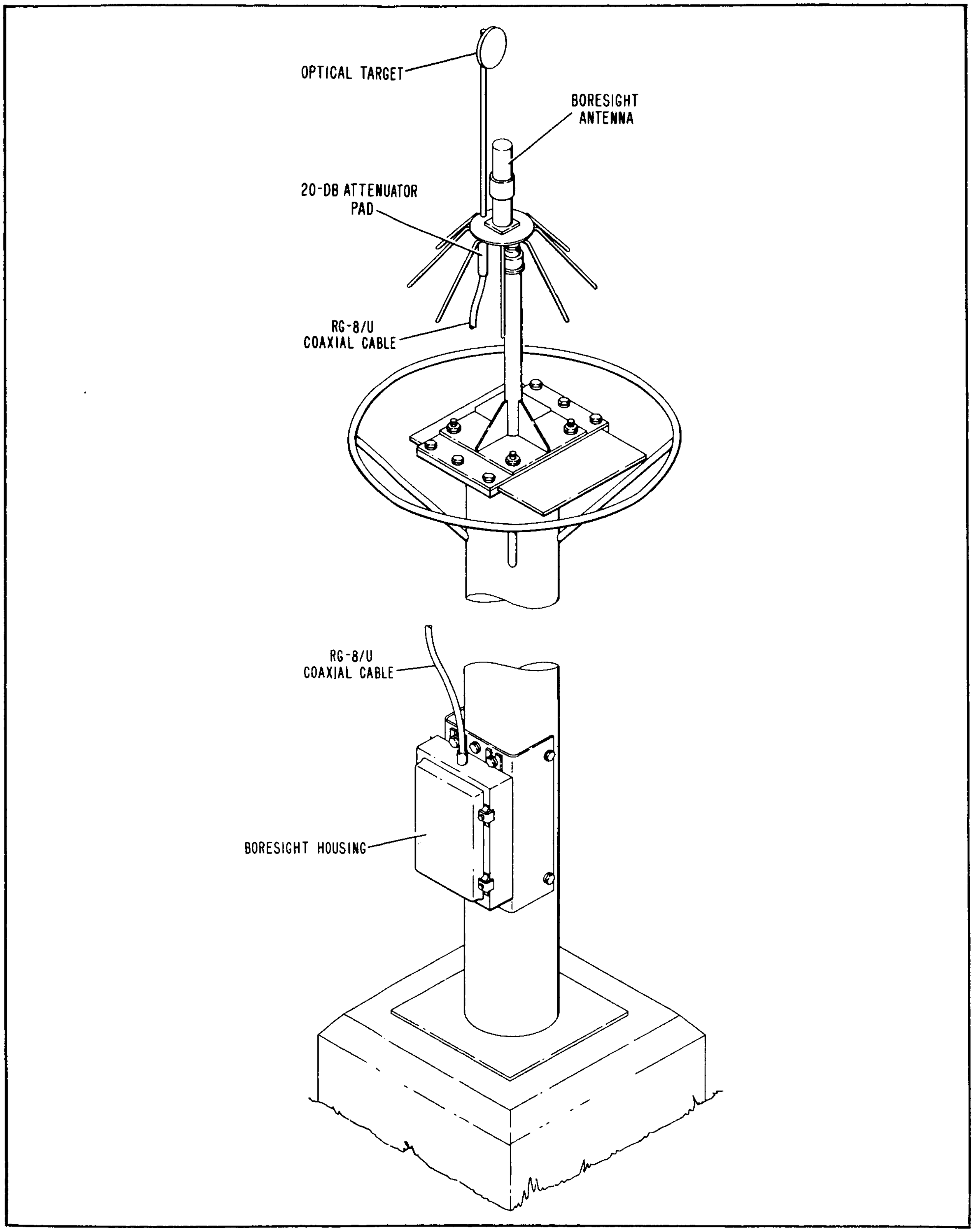


Figure 2-6. Active Acquisition Aid Boresight Transmitter and Antenna Installation

(5). BORESIGHT TRANSMITTER AND ANTENNA

The active acquisition aid boresight transmitter and antenna are mounted on the boresight antenna tower; the transmitter on a bracket near the base of the tower and the antenna on the top of the tower. The location of the boresight tower at the site is shown on figure 1-12. Table 2-1 lists the installation hardware for the bracket which supports the transmitter and for the special support, mounting plate, and two clamps which mount the boresight antenna. Details of the installation are shown on figure 2-6.

2-3. INTERCONNECTING CABLING

A. ELECTRICAL INTERCONNECTIONS

The acquisition system interconnecting cabling diagram shows the connections between the acquisition system and equipment of other systems. Detailed information on the cabling shown on figure 7-6 is not included in this manual. It is provided in a separate book, the "Installation Wiring Information" chart, part number L683173-18. For information on the wiring between units of the active acquisition aid, refer to the equipment manual. The FPS-16 radar cable termination box interconnecting wiring information is provided in the Radar Tracking System Manual, MS-101.

B. CABLE INSTALLATION

The physical installation of equipment interconnecting cabling is not covered in this manual. Information on physical installation of interconnecting cabling is included in the installation wiring information chart (refer to the previous paragraph) and is provided directly to the site on separate drawings.

2-4. PRE-OPERATIONAL CHECKS

A. COMPONENT (UNIT) CHECKS

Pre-operational checks of the components of the acquisition system are given in the applicable equipment manual.

B. SYSTEM CHECKS

No pre-operational checks are required for the overall acquisition system. Operational system checks are described in section III. It should be kept in mind that any malfunctions involving synchros which occur the first time the system checks are run are likely to be caused by incorrect interconnecting wiring of the synchro circuits. Refer to section V and particularly to figure 5-1 for information on trouble shooting synchro circuit malfunctions.

SECTION III
SYSTEM OPERATION

3-1. GENERAL

A. This section contains system operational checks and normal and emergency operating procedures for the acquisition system. Initial turn-on procedures, complete, detailed operating procedures, and system operational checks for the active acquisition aid are given in the applicable equipment manual, listed in table 1-II.

B. For proper operation of the acquisition system, it is necessary that all operators involved have a thorough knowledge and understanding of the makeup, capabilities, and limitations of the overall system and the equipment connected to it. Refer to Sections I and IV of this manual and the active acquisition aid equipment manual.

3-2. SYSTEM OPERATIONAL CHECKS

Detailed procedures for checking the operation of the active acquisition aid, except the radar display panel, are given in the equipment manual. The operational checks for the radar display panel are described below. All of these checks are to be performed after initial turn-on of the equipment and again shortly before each Mercury operation.

A. D-C INDICATIONS

(1). With the active acquisition aid and FPS-16 energized, instruct the FPS-16 radar operator to depress the "DATA ACCEPTABLE-YES" pushbutton on the radar range indicator panel. This action turns on the "VALID TRACK" indicator on the active acquisition aid control console radar display panel. Remove the indicator display screen and check to see that both color filters are in place and that both lamps are lit.

(2). Switch the active acquisition aid successively to the manual and automatic modes of operation. Instruct the FPS-16 radar operator to check the appropriate d-c mode indicators on the IRACQ panel.

B. SYNCHROS

(1). Set the active acquisition aid to zero degrees azimuth and elevation as indicated by the control console displays.

(2). Instruct the FPS-16 radar operator to slave the radar to the active acquisition aid.

(3). Change the active acquisition aid antenna through 360 degrees in azimuth and 90 degrees in elevation in 30-degree steps. At each 30-degree step in azimuth and elevation, compare the displays from the radar (on the control console radar display panel, figure 3-1) with the displays from the active acquisition aid antenna. The radar displays should agree with the active acquisition aid displays within ±1.5 degrees.

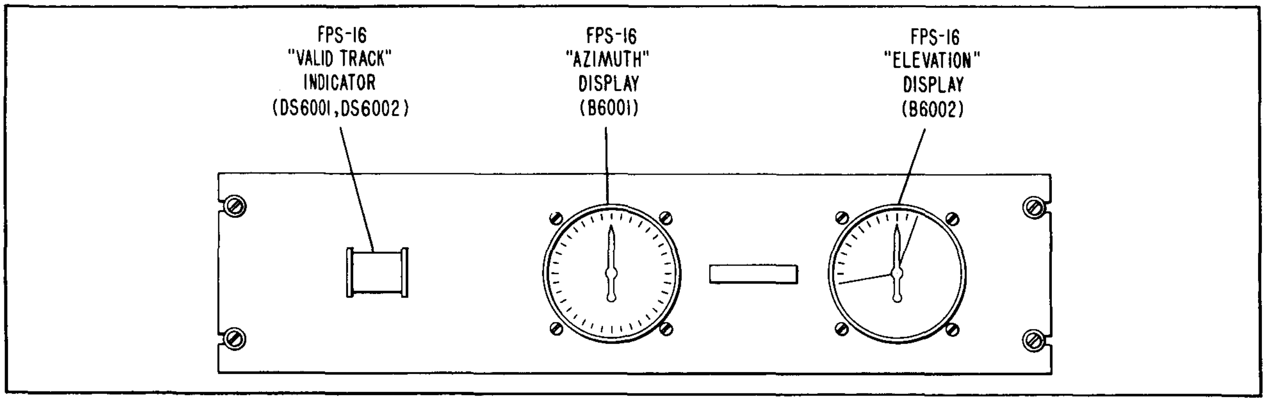


Figure 3-1. Active Acquisition Aid Control Console Radar Display Panel

3-3. NORMAL OPERATING PROCEDURE

A. OPERATING INSTRUCTIONS

(1). Turn on the active acquisition aid in accordance with the instructions in the equipment manual.

(2). Perform the system operational checks described in paragraph 3-2.

(3). Set the active acquisition aid in the manual mode of operation and position it in accordance with predicted data.

Note

When the active acquisition aid is to be operated in conjunction with the FPS-16, be sure that synchro reference "LOCAL-REMOTE" switch S101 on the active acquisition aid is in the "REMOTE" position. Otherwise, the active acquisition aid and the FPS-16 synchro circuits will be operated with different reference voltage sources and error will be introduced into the synchro data.

(4). By intercom, instruct the FPS-16 radar operator to position the radar to approximately the same azimuth and elevation as the active acquisition aid.

(5). Check the position of the radar display synchros on the radar display panel and then instruct the radar operator to slave his antenna to the active acquisition aid.

(6). Check the system slaving accuracy: the radar displays should not differ by more than ± 1.5 degrees from the active acquisition aid displays.

B. INITIAL ACQUISITION-ACTIVE ACQUISITION AID

(1). In the Mercury capsule there are two telemetry transmitters which operate at different frequencies in the 225 to 260-megacycle band. The transmitters operate at the same power, and normally either frequency may be used in tracking the capsule. Therefore, for initial acquisition and subsequent tracking, the active acquisition aid may be set at either frequency unless difficulty in acquisition and tracking is encountered. If difficulty is encountered, try the other frequency to see if better results are obtained.

(2). Watch the signal strength indicators and panalyzer and listen for telemetry audio. These will be the first indications that the capsule is in range.

(3). As soon as there are indications that a signal is being received, switch the active acquisition aid into automatic tracking and closely monitor its action as shown on the control console synchro displays.

(4). At low elevation angles the active acquisition aid may track a signal reflected from the ground. Therefore, closely monitor the control console synchro displays, particularly the elevation display. If the indicated elevation angle goes below the known horizon, switch to the manual elevation mode and position the antenna for minimum elevation error signal indication at an elevation above the horizon. Manually track the capsule in elevation until it is a few degrees (five to ten) above the horizon and then switch back to fully automatic tracking (both channels in automatic).

C. INITIAL ACQUISITION— FPS-16 RADAR

The FPS-16 radar should remain slaved to the active acquisition aid until a capsule signal is received by the active acquisition aid (unless of course the radar should acquire the capsule before the active acquisition aid does). When a capsule signal is received by the active acquisition aid at a low elevation angle, the elevation channel of the FPS-16 should be switched from the slaved mode, and elevation searching begun. The azimuth channel of the radar should remain slaved to the active acquisition aid (through the acquisition bus) and elevation searching should be continued until the radar acquires the capsule or until the elevation of the capsule is sufficient to insure accurate tracking by the active acquisition aid (at least 10 and preferably 15 degrees above the horizon). If this elevation is reached before the radar acquires the capsule, the elevation channel of the radar should be switched from the searching mode and again be slaved to the active acquisition aid until the capsule is acquired.

D. TRACKING

(1). After the radar acquires the capsule and is in the fully automatic tracking mode, continue to track the capsule with the active acquisition aid so that data will be available to the radar for re-acquisition if tracking is lost before the capsule is out of range.

(2). Should the active acquisition aid lose the track (radar still tracking automatically) switch the active acquisition aid to the manual mode of operation. Manually position the antenna to the azimuth and elevation positions indicated by the FPS-16 radar display synchros until the active acquisition aid re-acquires the capsule. Should both the radar and the active acquisition aid lose the capsule, proceed as follows:

(a). Switch the active acquisition aid to the manual mode of operation.

(b). Slave the FPS-16 radar to the active acquisition aid.

(c). Manually position the active acquisition aid antenna to the best position (estimated or in accordance with predicted data if available) for re-acquisition of the capsule.

3-4. EMERGENCY OPERATING PROCEDURE

A. An emergency condition exists when the active acquisition aid is unable to track the capsule automatically. The following paragraphs describe the operating procedures for the active acquisition aid under this condition.

(1). Switch the active acquisition aid to the manual mode of operation and position the antenna for null indications on the error signal meters on the control console meter and switch panel. This action points the antenna at the capsule. Continue to adjust the antenna position for null error signal indications to keep the antenna pointed at the capsule for the duration of the pass.

(2). If the capsule cannot be tracked manually by error signal indications, position the antenna for maximum indication on the signal strength meter on the meter and switch panel. Like the nulling of the error signal meters, positioning the antenna for maximum signal strength indication keeps it pointed at the capsule.

SECTION IV
THEORY OF OPERATION

4-1. GENERAL

This section presents the theory of operation of the acquisition system on a block diagram level. For detailed information on the active acquisition aid, refer to the applicable equipment manual, listed in table 1-II.

A. FUNCTION OF THE SYSTEM

As was described in Section I, the function of the acquisition system is to take the best data available on the capsule's azimuth and elevation at any given time and make it available on the acquisition bus for use by the FPS-16 radar. (The acquisition bus is the line which connects acquisition data from the active acquisition aid to the radar.) This data is taken from synchro transmitters which are mechanically coupled to the active acquisition aid antenna. The radar uses the data as an aid in acquiring the capsule for automatic tracking. As soon as it begins automatic tracking, the radar stops using data from the acquisition bus. However, under most conditions during a capsule pass, data from the bus is still available for use in re-acquiring the capsule if the radar loses automatic tracking before the capsule is out of tracking range.

B. NORMAL OPERATION

The following is a description of the normal sequence of availability and use of acquisition information during a typical pass of the capsule. This description is given as an aid in understanding the overall operation of the acquisition system. It should be noted that some variations from the normal sequence are possible. These variations are not discussed in the following description, but should be apparent once the capabilities of the system are understood.

(1). Prior to the pass, predicted target position coordinates — azimuth, elevation, range, and time — are sent to the site in plain text from the Goddard Space Flight Center. Coordinates for four or five different times along the orbit are sent: time of arrival at 700 nautical miles range, 30 seconds later, 60 seconds later, 90 seconds later and time for position just past zenith when a zenith pass is expected. The first set of coordinates is read over the intercom to the active acquisition aid operator who manually positions the active acquisition aid antenna accordingly. The FPS-16 radar is then slaved to the active acquisition aid. If acquisition (automatic tracking) of the capsule is not accomplished by the radar at the time specified by the first set of predicted coordinates, the next three of the remaining sets of coordinates are read and set into the system at the times given. The coordinates just past zenith are used as an aid in reacquiring the capsule if automatic tracking is lost as it passes overhead.

(2). The active acquisition aid acquires the capsule, and data from the active acquisition aid is supplied to the FPS-16 via the acquisition bus. As seen as the FPS-16 radar acquires the capsule and begins tracking it automatically, it stops using the data on the acquisition bus. The active acquisition aid, however, continues independent automatic tracking. These conditions—the radar and the active acquisition aid both tracking automatically—are the optimum for the remainder of the capsule pass. They are continued until the capsule goes beyond the range of the FPS-16 radar.

4-2. DETAILED DISCUSSION

A. OVERALL SYSTEM

(1). A block diagram of the acquisition system is shown in figure 4-1. Synchro position, or slaving, data is connected from the active acquisition aid to the FPS-16 by the acquisition bus (heavy lines on figure 4-1). When the active acquisition aid is tracking the capsule, this data is available for slaving the FPS-16 at the option of the FPS-16 operator. Synchro display data, which allows the active acquisition aid operator to monitor the position of the FPS-16 antenna, is connected from the FPS-16 to synchro display receivers on the active acquisition aid control console radar display panel.

(2). D-c indications of operating mode are connected between the FPS-16 and the active acquisition aid. As shown on figure 4-1, an indicator on the active acquisition aid control console radar display panel is lit whenever the FPS-16 is in the automatic tracking (valid track) mode of operation. The operating mode of the active acquisition aid is shown by two indicators on the FPS-16 IRACQ panel. There is one indicator for manual operation and one for automatic.

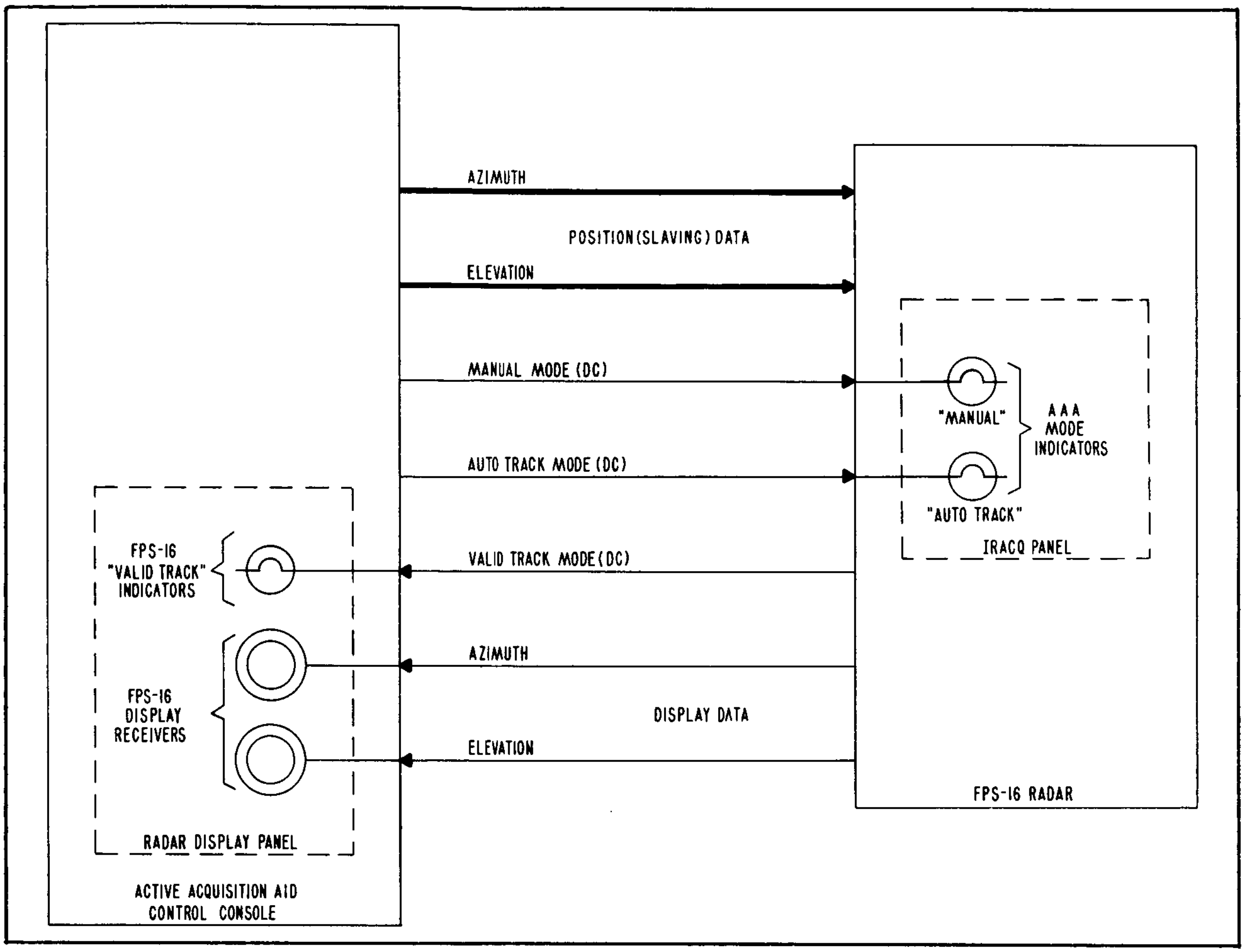


Figure 4-1. Acquisition System, Block Diagram

B. ACTIVE ACQUISITION AID

(1). GENERAL

(a). One of the problems associated with the use of narrow-band, precision-tracking radars is the acquisition of a small, high-speed target. The problem is, simply, that the target passes through the radar beam so quickly that the radar and/or operators have very little time in which to recognize the target and switch into automatic tracking. The problem is solved by the use of the active acquisition aid, which has a wide antenna pattern (20 degrees), but tracks with accuracy (within ±0.5 degree) sufficient to point a narrow-beam radar at the target.

(b). The relative cones of coverage of the radar and the active acquisition aid are represented in figure 4-2. The active acquisition aid cone of coverage on the illustration does not represent an actual beam, since the active acquisition aid has no transmitter; instead, it represents a receiving antenna pattern. Because of its wide cone

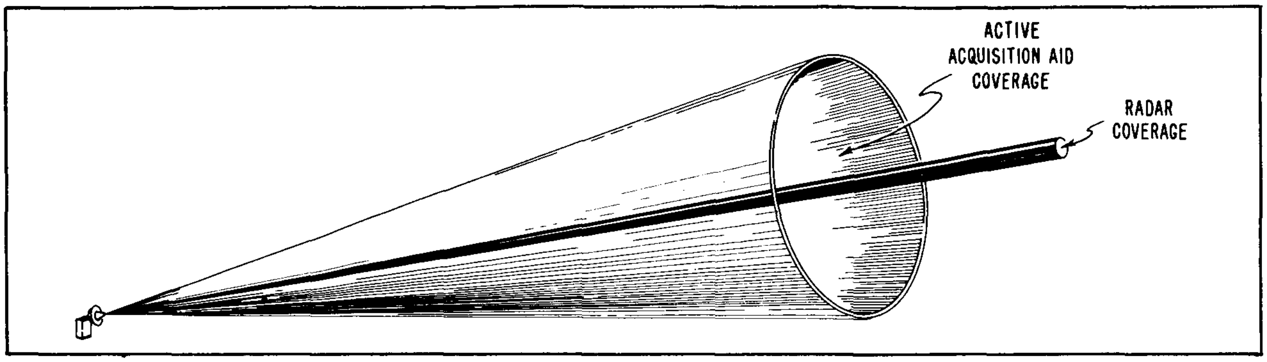


Figure 4-2. Relative Coverage by Active Acquisition Aid and Radar

of coverage, the active acquisition aid does not require precise antenna pointing to acquire its target, the Mercury capsule. The antenna is pointed in accordance with the best data available. For initial acquisition, as the capsule comes over the radio horizon, this data is based on computations of the capsule's orbit. For reacquisition in the event automatic tracking is lost during a pass of the capsule, the best data is in most cases simply an estimate based on the capsule's position when the track was lost. As soon as the capsule comes within its 20-degree cone of coverage, the active acquisition aid acquires an automatic track and steers itself to boresight; i.e., it points its antenna so that the capsule is in the center of its cone of coverage. Position data (capsule azimuth and elevation) is then put out by the active acquisition aid onto the acquisition bus. The FPS-16 radar is slaved to this data and is therefore pointed at the capsule. The active acquisition aid continues to track the capsule, and the radar remains slaved until it acquires the capsule and begins independent, automatic tracking. This then is the function of the active acquisition aid: to acquire and track the capsule in azimuth and elevation and provide data which enables the FPS-16 radar to acquire the capsule.

(2). BLOCK DIAGRAM DESCRIPTION (Figure 4-3)

(a). The active acquisition aid quad-helix antenna receives two telemetry signals transmitted by the capsule. These signals (at frequencies T1 and T2, also designated as frequencies A and B) are fed from the helical antenna elements to an r-f bridge composed of the four hybrid rings. For each frequency, three outputs from the r-f bridge are used. These outputs are a reference signal (vectorial sum of the signals from the four antenna elements), a signal (azimuth error) which depends on the azimuth displacement of the antenna from boresight, and a signal (elevation error) which depends on the elevation displacement of the antenna from boresight. The

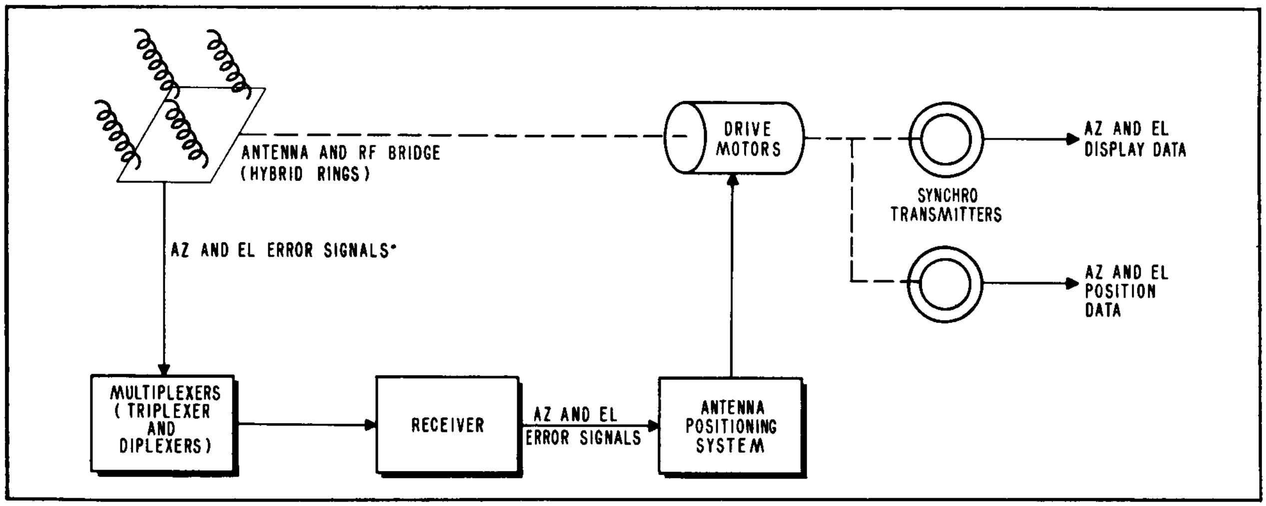


Figure 4-3. Active Acquisition Aid, Simplified Block Diagram

derivation of the azimuth and elevation error signals is based on a phase comparison in the r-f bridge of the signals from the antenna elements. When the antenna is off boresight in azimuth, the signals from the two elements on the right side of the antenna differ in phase from the signals from the two elements on the left side; when the antenna is off boresight in elevation, the signals from the two top elements differ in phase from the signals from the two bottom elements. Comparison of these phases yields the error signals.

(b). The azimuth and elevation error signals and the reference signal are fed from the r-f bridge through the triplexer and diplexers, for frequency separation, to the receiver. The first and second r-f amplifiers and the first mixer and i-f amplifier of the receiver are in the r-f housing unit. The balance of the receiver circuits are in the receiver cabinet. The receiver locks onto one or the other of the telemetry frequencies, as selected by switch.

(c). The output of the receiver consists of azimuth and elevation error signals to the antenna positioning system. The antenna positioning system comprises, in essence, electronic and electro-mechanical servo amplifiers and antenna drive motors. This system continuously positions the antenna for minimum, or null, error signals out of the receiver. Thus, the antenna is kept pointing at the target which is being tracked.

(d). Two pairs of synchro transmitters are mechanically coupled to the antenna. One of these pairs transmits antenna azimuth and elevation position data to the acquisition bus. The other pair transmits azimuth and elevation display data for display on the active acquisition aid control console. The position data transmitters provide the principal output of the active acquisition aid; these transmitters are the means by which acquisition and tracking information is sent to the FPS-16 radar. (Refer to the synchro circuit connection schematics in section VII.)

(e). On the meter and switch panel of the control console, there are azimuth and elevation error meters which permit manual tracking with the active acquisition aid in the event that part of the automatic system is inoperative or when it is not desired to use fully automatic tracking. These meters indicate the amount and direction of antenna pointing error. (The errors indicated by the meters are essentially the same as those supplied to the antenna positioning system during fully automatic tracking.) For manual tracking with the error meters, the operator simply turns the manual handwheels on the control console to null the error indicated on the meters.

(f). Manual pointing of the antenna for maximum strength of received signals can be performed with the aid of the signal strength meter on the active acquisition aid control console. This meter indicates the strength of the signal in the sum channel of the active acquisition aid. For manual tracking by means of received signal strength, the operator turns the handwheels on the console for maximum signal strength as indicated on the meter.

(g). The active acquisition aid has two modes of operation which are used at White Sands. These are automatic tracking and manual tracking. (A third mode, slaved, is not used.) As previously mentioned, d-c indications of these modes go from the active acquisition aid to the FPS-16 radar to permit the radar operator to monitor the operating status of the active acquisition aid.

C. CONTROL CONSOLE RADAR DISPLAY PANEL

(1). D-C INDICATION

Mounted on the radar display panel is a "VALID TRACK" indicator which when lit, indicates the FPS-16 radar is in the automatic tracking mode of operation. When the radar is tracking the capsule automatically, the radar operator depresses the "VALID TRACK" switch on the radar mode control panel, which energizes relay K6001 on the control console radar display panel and thereby applies 28 VDC to indicator lamps DS6001 and DS6002. (For complete circuit connections, see figures 7-1 and 7-5.)

(2). SYNCHRO CIRCUIT

Display data from the FPS-16 radar is fed to the active acquisition aid control console radar display panel. Azimuth and elevation data is taken from two separate synchro transmitters in the radar and is routed through TB87510, the contacts of relay K6010 to synchro receivers B6001 (azimuth) and B6002 (elevation), where it is displayed. The purpose of relay K6010 is to protect the display receivers (B6001 and B6002) on the console radar display panel and the display data transmitters in the FPS-16 synchro reference voltage is not applied to the synchros in the console, but is applied to the synchros in the radar. (With reference voltage applied to one of two synchros connected together but not applied to the other, excessive stator currents flow and both of the synchros are likely to be damaged.) Relay K6010 is energized by console synchro reference voltage; thus, when synchro reference voltage is not applied to the console, K6010 is de-energized and the stator circuits of B6001 and B6002 are disconnected from the radar. (For complete circuit connections see figures 7-1 and 7-2.)

D. SYNCHROS

(1). TRANSMITTERS AND RECEIVERS

(a). A standard synchro transmitter or receiver, such as is used in the acquisition system, may be considered as a single-phase transformer with a rotatable primary and a stationary, wye-wound secondary. Accordingly, the primary winding is called the rotor, and the secondary windings are called the stator. The two terminals of the rotor windings are designated R1 and R2, and the terminals of the three stator windings are designated S1, S2, and S3.

(b). A reference, or excitation voltage (115 VAC, 60 cycles for the synchros in the acquisition system) is applied to the rotor of a synchro. (See figure 4-4). This reference voltage applied to the rotor of the synchro induces voltages in the stator windings. The magnitude of the voltage induced in a given stator winding depends on the angle which the rotor makes with that stator winding, and the phase angle of the voltage in a stator winding with respect to the rotor voltage is always zero or 180 degrees. The voltages in the windings of a synchro stator are shown in figure 4-5. The curves in the illustration are plots of the voltage magnitudes and phase against the angle of the rotor. The voltage across each stator winding (i.e., from the winding terminal to the common connection of the three windings) varies from 52 VAC (rms) of one phase polarity through zero to 52 VAC of the opposite phase polarity as the rotor is turned. Due to the way the rotor and stator windings are arranged on a synchro, these curves are sinusoidal. However, they should not be confused with timegraphs of sinusoidal voltages. All of the voltages in a synchro system are a-c, they are either in phase or 180 degrees out

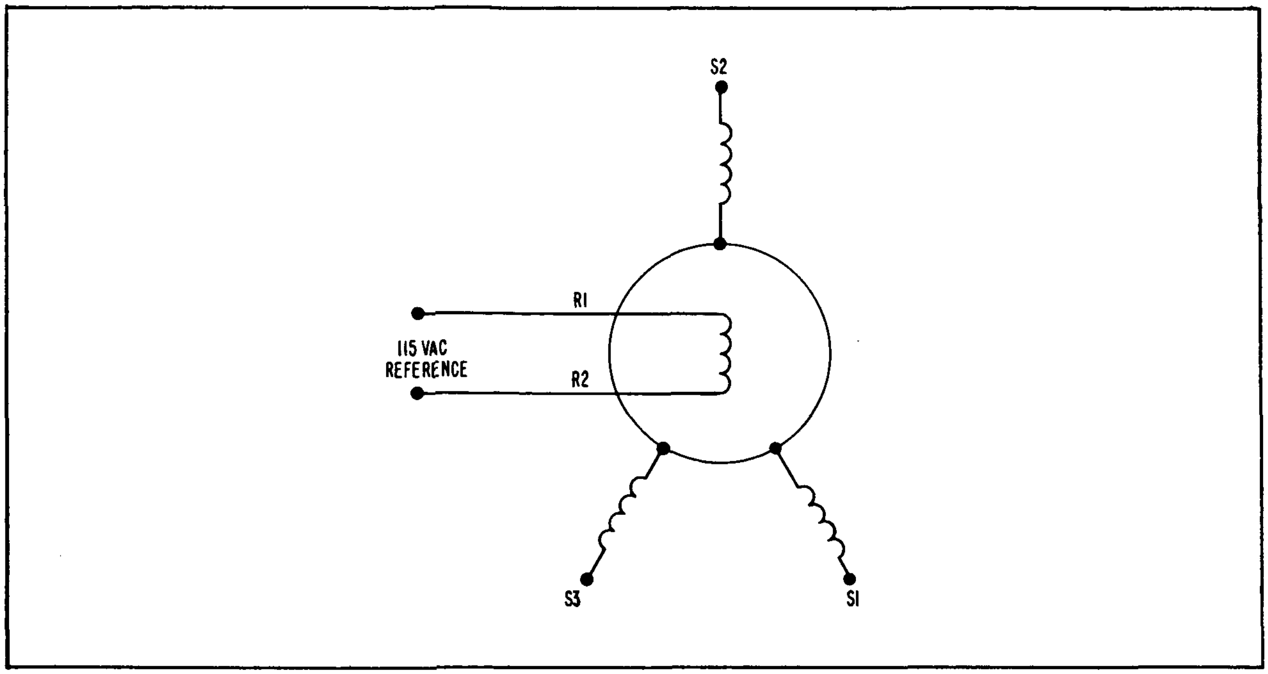


Figure 4-4. Synchro Transmitter or Receiver, Schematic Diagram

of phase with each other, and their effective (rms) values vary with the angle of the rotor, as shown on the illustration.

(c). In practice, no external connection is made to the common connection of the three stator windings, and the synchro system stator voltages are taken between the three pairs of windings: S2 and S1, S2 and S3, and S1 and S3. The voltage magnitude and phase between these pairs of windings is shown in figure 4-6 for varying rotor angles.

(d). The simplest form of synchro system consists of a transmitter and a receiver. A transmitter and a receiver which are suitable for use in the same system generally are electrically identical, but differ somewhat mechanically. The most notable mechanical difference is the use of a damper on the receiver in order to prevent it from oscillation. The transmitter, being mechanically coupled to an antenna or handwheel through a gear train, requires no damper. Hence, if mechanical coupling can be arranged, a receiver can be used as a transmitter, but a transmitter generally cannot be used as a receiver.

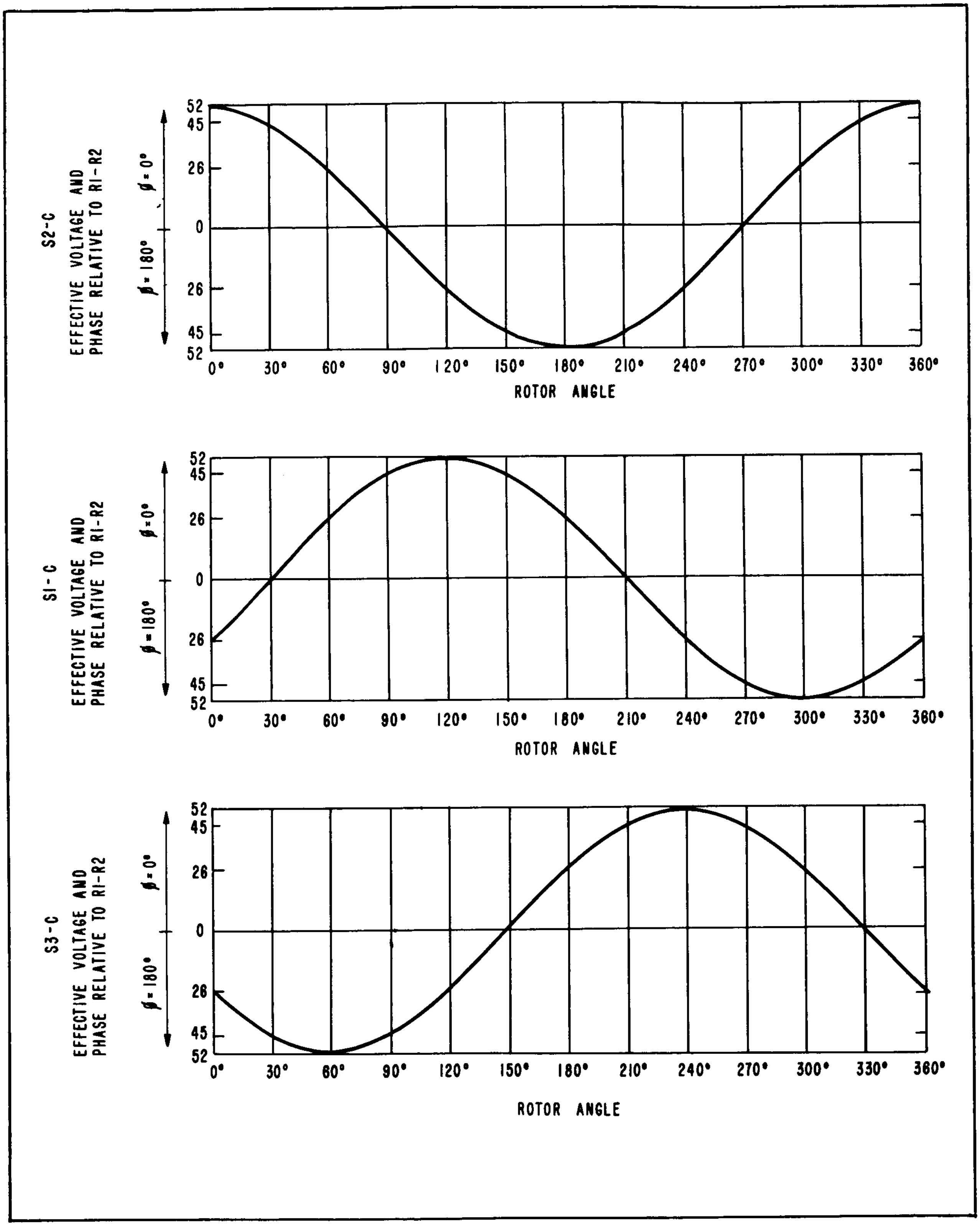


Figure 4-5. Voltage in Synchro Stator Windings

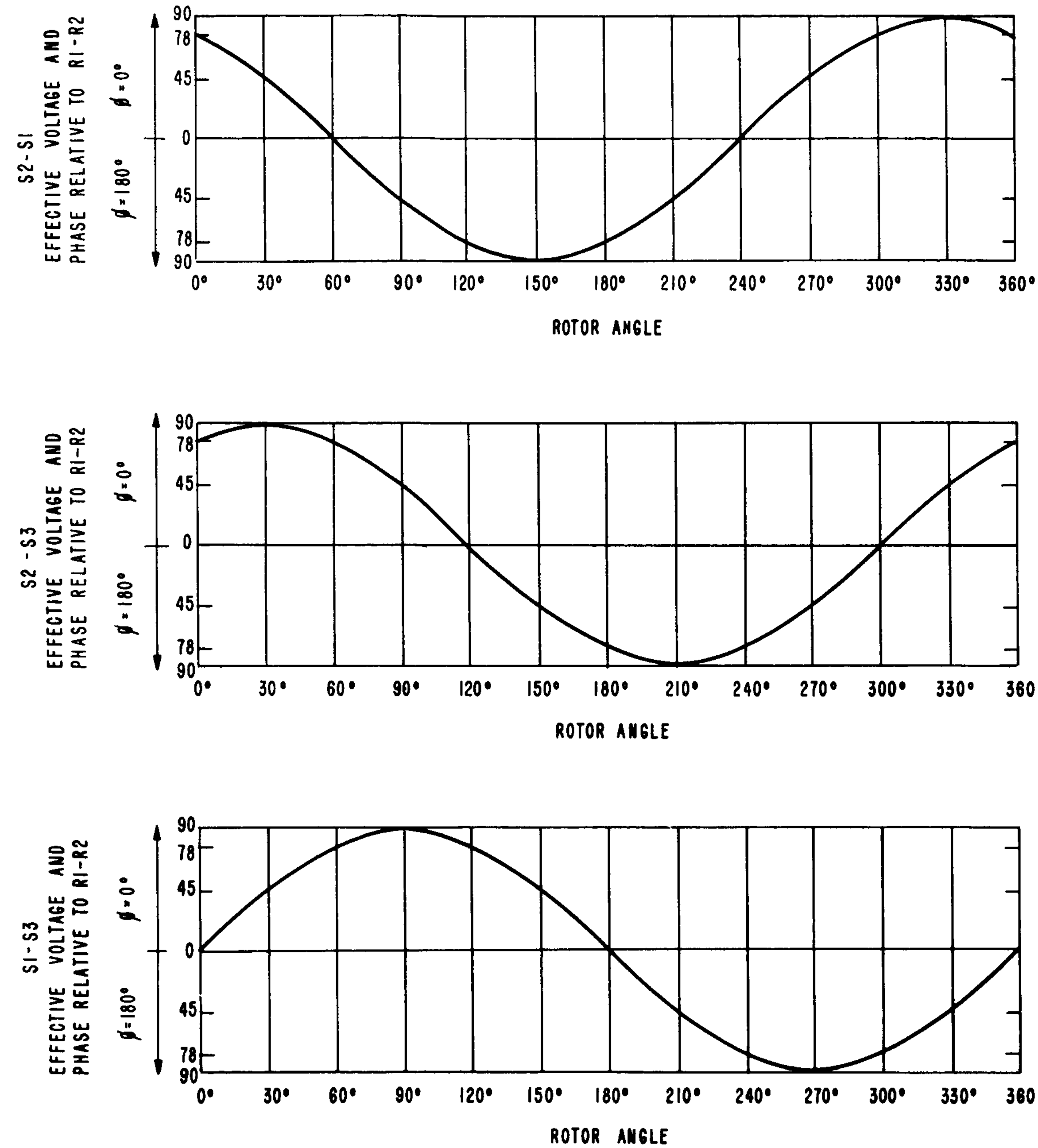


Figure 4-6. Voltages between Synchro Stator Windings

(e). The manner in which a synchro system works is illustrated in figures 4-7 and 4-8. The stator windings of the transmitter are connected to the corresponding windings on the receiver; S1 to S1, S2 to S2, and S3 to S3. The rotor windings of the transmitter and receiver are connected in parallel and are supplied by 115 VAC reference.

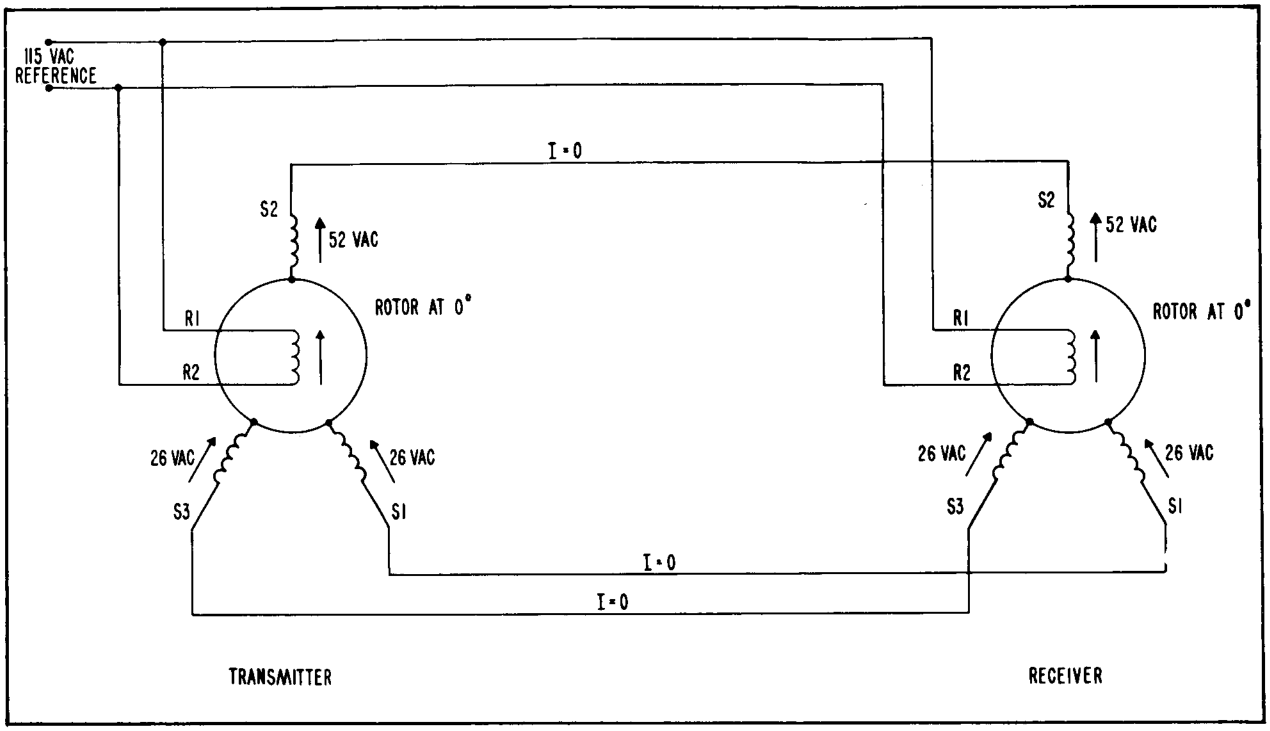


Figure 4-7. Simple Synchro System with Transmitter and Receiver Rotors at the Same Position, Schematic Diagram

Note

All of the rotor windings in a synchro system must be connected to a common reference voltage source. Otherwise, phase differences between voltage sources will cause inaccuracies in the system.

With the reference voltage applied and both of the rotors at zero degrees, as shown in figure 4-7, voltages in the stator windings are 52 VAC for the S2 winding and 26 VAC each for the S1 and S3 windings. The arrows on the illustration adjacent to the windings indicate relative instantaneous current direction (relative phase). As can be seen from figure 4-7, with both the transmitter and receiver rotors at the zero position, the magnitudes of the voltages induced in the stator windings of the transmitter and receiver are the same, and the phases are such that no current flows through the windings. With no current in the windings, no torque is developed and both synchros remain at rest. This condition of dynamic balance (voltages and phases such that no current flows in the stator windings) exists whenever, but only so long as, the rotors of the transmitter and receiver are at the same angular position.

(f). If the synchro receiver is held at one position and the transmitter turned to another position, unbalanced stator voltages are developed and current flows in the windings. An example of this condition is shown in figure 4-8. The rotor of the transmitter is turned to 30 degrees, inducing stator voltages of the magnitudes and relative phases shown on the illustration. (For the magnitude and relative phase of the induced stator voltages at any position of the rotor, see figure 4-5.)

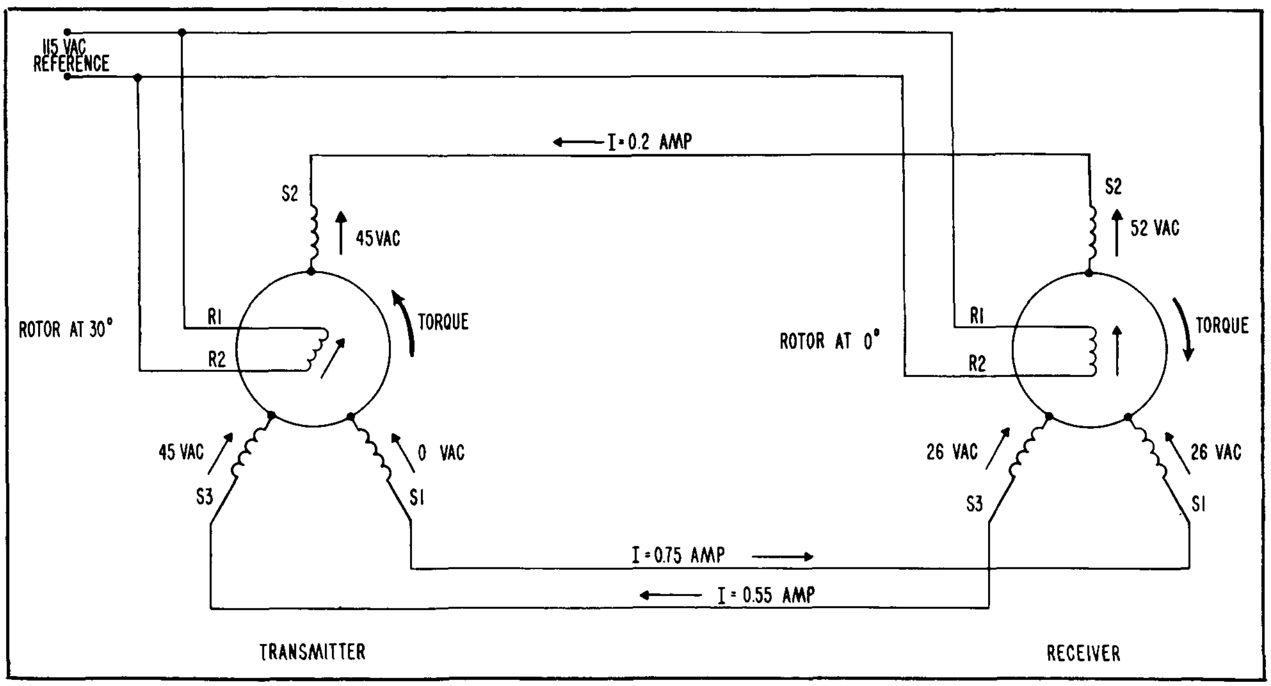


Figure 4-8. Simple Synchro System with Transmitter and Receiver Rotors at Different Positions, Schematic Diagram

The rotor of the receiver, however, is at a different position, zero degrees, and the voltages induced in its stator windings are different from those in the stator of the transmitter. Currents with the relative phases shown flow in the stator windings. The magnitudes indicated for the currents are typical values. These currents cause torque to be applied to the rotors of the synchros and both of the rotors try to turn. Under the conditions shown on figure 4-8, the transmitter rotor will try to turn in a counterclockwise direction and the receiver rotor in a clockwise direction. The transmitter rotor, when it is mechanically coupled to an antenna or a handwheel, is not free to turn, but the receiver rotor is free to turn. Thus, the receiver rotor turns to the same position as the transmitter rotor and the system comes to dynamic rest. In the same manner, if the transmitter rotor is turned to some new position, the receiver rotor follows. The synchros used in the acquisition system have sufficient sensitivity that as long as reference voltage is applied and the units are operating normally, a receiver will always follow the transmitter to which it is connected within a small fraction of a degree; the receiver is always at virtually the same position as the transmitter, regardless of whether the transmitter is stationary or is being turned. Hence, a pointer or dial attached to the receiver rotor provides an indication of the angular position of the device—in most cases an antenna—to which the transmitter rotor is coupled.

(g). A variety of nomenclature is applied to synchros. The most common of these are listed and explained below:

1. Torque receiver (TR): a synchro receiver.

2. Torque transmitter (TX): a synchro transmitter which can drive a relatively large mechanical load (on the receiver or receivers connected to the transmitter).

3. Control transmitter (CX): a synchro transmitter which can drive only a relatively small mechanical load (on the receiver or receivers connected to the transmitter).

Note

Both torque transmitters and control transmitters are synchro transmitters as described in the previous paragraphs, and except for the amount of load they can drive, they are the same.

4. Synchro generator: a synchro transmitter.

5. Synchro motor: a synchro receiver.

6. Control Transformer (CT): this device is described in the following paragraph.

7. Selsyn, Autosyn: trade names for synchros.

(2). CONTROL TRANSFORMERS

(a). The control transformer is a type of synchro unit widely used in automatic control systems. Its function is to supply an a-c voltage whose magnitude and phase polarity depend on the difference between the angular position of its rotor and the rotor of the synchro transmitter which is connected to it. Control transformers are used in various places in the antenna positioning systems which are part of or are connected to the acquisition system.

(b). Control transformers are similar to synchro transmitters and receivers, but differ from them in several important respects:

1. The rotor winding of a control transformer is never connected to an a-c supply and therefore induces no voltage in the stator windings. As a result, the stator current is determined only by the impedance of the windings, which is high, and it is not appreciably affected by the rotor's position. (A matched set of delta-connected capacitors is connected across the stator leads near the control transformer. These capacitors correct the lagging power factor of control transformer coils and reduce the current drawn from the synchro transmitter.) Also, there is no appreciable current in the rotor, and the rotor does not tend to turn to any particular position when voltages are applied to the stator.

The rotor of a control transformer is always turned by some mechanical device such as an antenna. (Or more specifically, by gearing between an antenna and the control transformer.)

2. The zero position of a control transformer is that at which the rotor is at right angles to the S2 stator winding. (See figure 4-9). Note that this zero position differs by 90 degrees from that of a transmitter or receiver (figure 4-7).

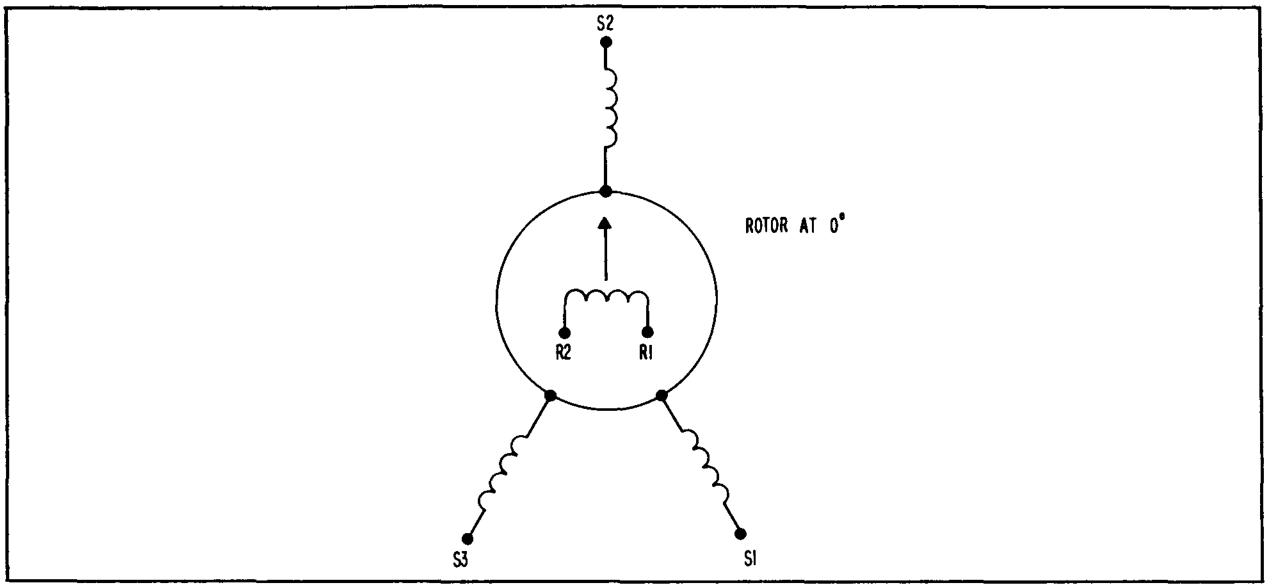


Figure 4-9. Control Transformer, Schematic Diagram

(c). The manner in which a control transformer is connected in a system is shown in figure 4-10. The stator windings of the control transformer are connected to the corresponding stator windings of a synchro transmitter. The rotor of the control transformer is usually connected to a servo amplifier. With a reference voltage (115 VAC) applied to the rotor of the transmitter, voltages are induced in the stator windings of the transmitter. These voltages are representative, by magnitude and phase polarity, of the angular position of the rotor. Since the stators of the control transformer and transmitter are connected, currents flow in the windings, and if the control transformer rotor is at any position except the same as or 180 degrees different from that of the transmitter rotor, voltage is induced in the control transformer rotor.

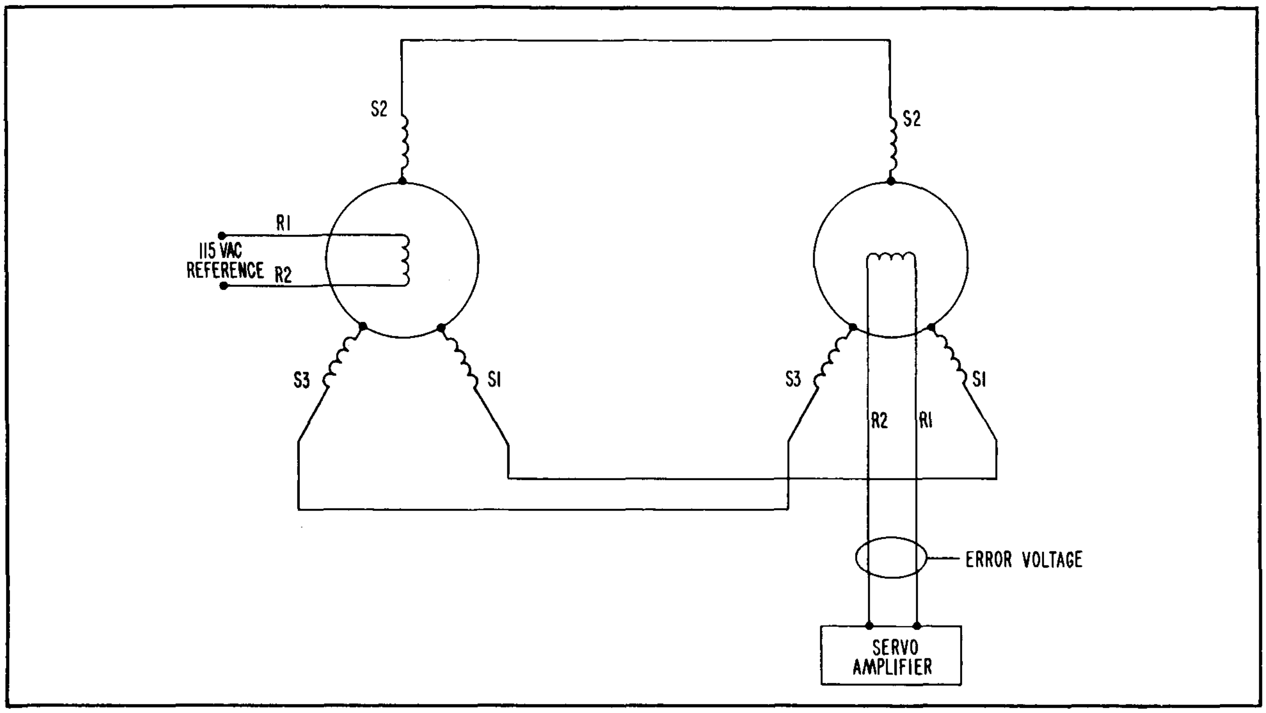


Figure 4-10. Control Transformer and Synchro Transmitter Connections, Schematic Diagram

(d). The voltage induced in the control transformer rotor when it is at a position different from the transmitter rotor depends in magnitude and phase polarity on the angular difference between the two rotors. The voltage variation for 360 degrees of angular difference between the positions of the two rotors is shown on figure 4-11. Note that the rotor voltage has two null points: at positions which are zero and 180 degrees different from the position of the transmitter rotor. When the control transformer rotor is between zero and 180 degrees relative to the transmitter rotor (voltage curve above zero line on figure 4-11), the control transformer rotor voltage is of one phase; between 180 and 360 degrees (voltage curve below the line on figure 4-11), it is of the opposite phase.

(e). For a description of how control transformers are used, refer to paragraph 4-2.E.

E. <u>TYPICAL SERVO SYSTEMS UTILIZING SYNCHROS</u>

In the acquisition system and the equipment associated with it there are a number of servo systems which utilize synchros. A simplified version of a servo

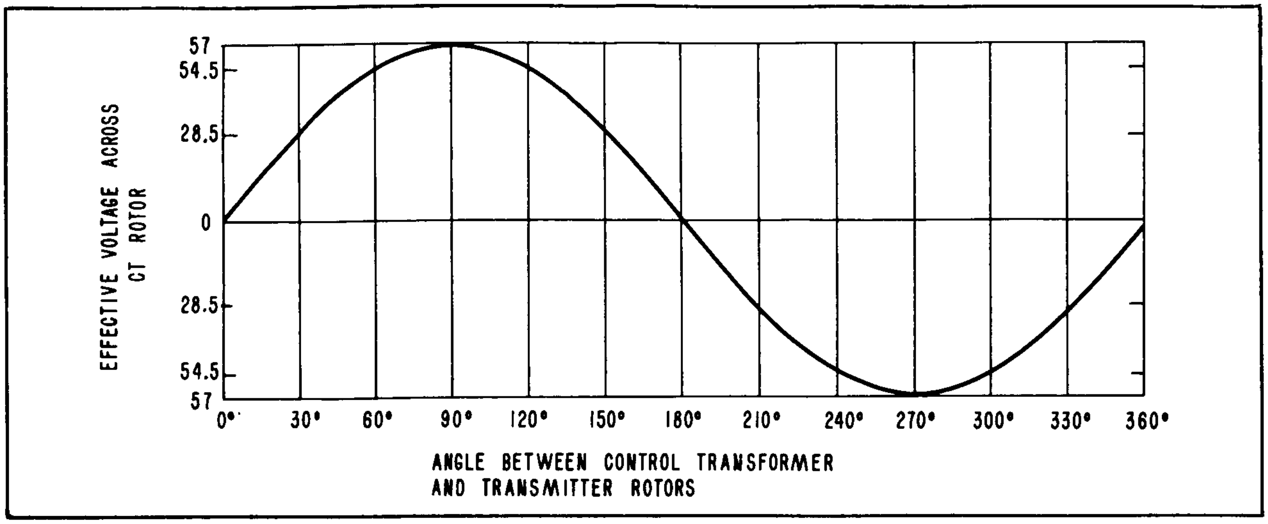


Figure 4-11. Voltage in Rotor Winding of Control Transformer

system of this type is described in this paragraph in order to provide a basic understanding of how mechanical position data is converted to electrical form, transmitted over a distance, and converted back to mechanical form. Figure 4-12 illustrates such a system.

(1). The principal elements of the system are a mechanical input (the handwheel on figure 4-12), a mechanical/electrical converter (the synchro transmitter), an electrical/mechanical converter (the servo loop consisting of the control transformer, the servo amplifier, and the servo motor), and a mechanical output, or load (the antenna).

(2). The output of the synchro transmitter is a function of the position of its rotor, which is mechanically coupled to the handwheel. The output of the synchro transmitter is connected to the control transformer, whose rotor may or may not be at the same angular position as that of the transmitter. Refer to paragraph 4-2.D. for a description of the operation of synchro transmitters and control transformers. When the control transformer rotor is not at the same position as the rotor of the transmitter, a voltage is developed in the control transformer rotor windings. The magnitude and phase polarity of this voltage depend on the angular difference between the positions of the two rotors. This voltage, the error signal of the servo loop, is applied to the servo amplifier, where it is amplified and applied to the variable-phase field winding of a two-phase motor. A reference voltage is applied to the fixed-phase field of the rotor. The direction of rotation of the motor depends on the phase of the error signal (relative to the reference voltage), and the speed of rotation of the motor

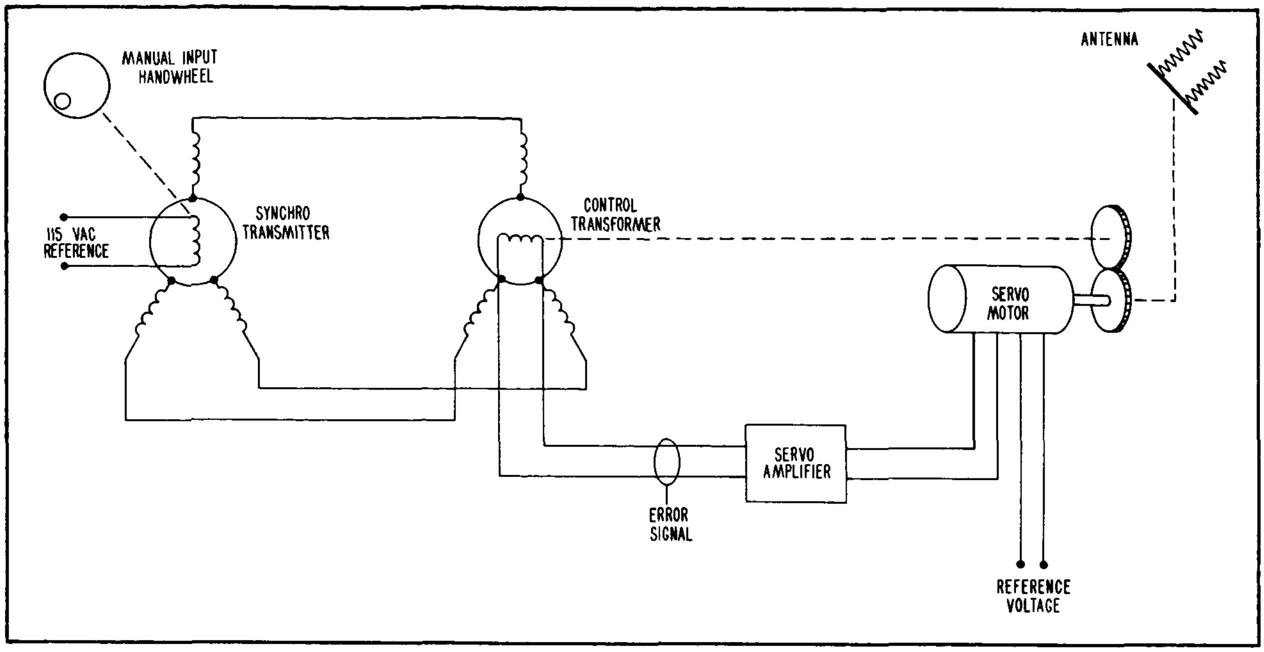


Figure 4-12. Typical Servo System Utilizing Synchros, Simplified Schematic Diagram

depends on the magnitude of the error signal, when no error signal is applied, the motor does not rotate. The motor armature is coupled through gearing to the rotor of the control transformer and to the mechanical load, in this case an antenna. The gearing and phase of signals in the servo loop are so arranged that whenever there is an error signal developed across the rotor of the control transformer, the motor turns in the direction which results in a reduction of the magnitude of the error. Stated another way, the motor drives the rotor of the control transformer so that it is always at very nearly the same position as the rotor of the synchro transmitter. Since the antenna is also driven by the motor, it too is kept at virtually the same position as the transmitter rotor. Thus, the antenna follows the handwheel which turns the synchro transmitter rotor.

(3). The servo systems actually used in the acquisition system and associated equipment are more elaborate than that just described, but the principal elements of the systems are the same. For instance, the active acquisition aid uses an amplidyne and a d-c servo motor in each channel of its antenna positioning system. The d-c servo motor, however, has exactly the same basic function as the two-phase, a-c motor on figure 4-12, and the amplidyne, is in its function, simply an additional two-stage servo amplifier.

SECTION V
SYSTEM MAINTENANCE

5-1. GENERAL

This section includes information, instructions, and procedures for preventive maintenance, trouble shooting, adjustments and repair, lubrication, special tools, and test equipment. System-level and general information is given for the equipment in the acquisition system. For detailed information on the equipment refer to the applicable equipment manual, listed in table 1-II.

WARNING

An antenna drive power cutoff switch and warning light is mounted below the platform of the active acquisition aid antenna. (Refer to Section II for the location of the switch.) When drive power is applied to the pedestal, the warning light is lit. The switch should be turned off (thus removing drive power from the pedestal) before going onto the antenna platform for maintenance or repair. For a schematic diagram of the active acquisition aid antenna safety circuit, which includes the cutoff switch and warning light, see figure 7-4.

5-2. PREVENTIVE MAINTENANCE

A. PREVENTIVE MAINTENANCE SCHEDULE

Table 5-I outlines the preventive maintenance procedures which are to be performed on all of the equipment in the acquisition system. Detailed procedures are discussed in paragraph 5-2. B. and the equipment manual.

B. PREVENTIVE MAINTENANCE PROCEDURES

(1). PAINTED SURFACES

Painted surfaces which have corroded should be sanded to remove all of the corroded material and then painted with a color which matches the original. If matching paint is not available, apply any available paint. When matching paint is

TABLE 5-I. PREVENTIVE MAINTENANCE SCHEDULE

Maintenance To Be Performed	Refer To
DAILY	
Check cover plates on pedestal for watertightness.	Equipment manual
Check all strip heaters for proper operation.	Equipment manual
Check azimuth and elevation limit switches for proper operation.	Equipment manual
Operate the pedestal both in azimuth and elevation for several minutes in order to keep the gearing well lubricated.	—
WEEKLY	
Check for corrosion of painted and plated surfaces. Clean and resurface all corroded areas.	Paragraphs 5-2. B. (1). and (2).
Check mechanical condition of switches to see that they are not loose or sluggish in their action. Replace any that appear likely to become defective	—
Check the lamps or bulbs in all indicators. Replace any that are burned out.	Equipment manual
Check for the presence of water in the azimuth oil sump.	Equipment manual
Check for the presence of water in the elevation gear compartment.	Equipment manual
Check the oil level in the azimuth oil reservoir.	Equipment manual
MONTHLY	
Perform general cleaning as necessary. Wipe off, vacuum off, or blow out dust, dirt, and sand. Clean dial plates (glass) on synchro displays.	—
Check and correct as necessary the general condition of equipment. Check cables and wiring for worn or frayed insulation, check connectors so see that they are free from corrosion and are tight, and check terminal board connections for tightness.	—
Check the operation of the azimuth oil pump.	Equipment manual
Check the oil level in the elevation oil reservoir.	Equipment manual
Check the cleanliness of the lubricants in the antenna control unit.	Equipment manual
Check the azimuth and elevation drive motor breakaway currents.	Equipment manual
Check the condition, placement, and dress of cables which wrap as the pedestal turns.	Equipment manual

TABLE 5-I. PREVENTIVE MAINTENANCE SCHEDULE (Cont.)

Maintenance To Be Performed	Refer To
BIMONTHLY	
Check the operation of the elevation oil pump.	Equipment manual
Check the azimuth and elevation amplidyne and drive motor brushes and commutators.	Equipment manual
Check the amount of backlash in the pedestal drive gearing.	Equipment manual
SEMI-ANNUALLY	
Check the mechanical friction of the pedestal (torque required for pedestal azimuth and elevation movement).	Equipment manual
YEARLY	
Disassemble azimuth and elevation amplidynes and clean and lubricate bearings and air circulating system.	Equipment manual
Disassemble azimuth and elevation drive motors and check the condition of the bearings.	Equipment manual

obtained, paint non-matching areas for sake of appearance.

(2). PLATED SURFACES

Corrosion of plated surfaces (cadmium, nickel or other) should be removed with sandpaper or emery cloth and sprayed or brushed with a clear lacquer. If a clear lacquer is not available, the corroded areas should be painted to prevent further corrosion until lacquer can be obtained.

5-3. TROUBLE SHOOTING

This paragraph provides information to aid in the isolation and correction of troubles in the acquisition system. It is concerned primarily with those malfunctions which affect the transmission of acquisition information. Since the d-c indication and synchro portions of the acquisition system are essentially independent of one another, they are treated separately in the following discussions.

A. D-C INDICATIONS

The d-c indication circuits in the acquisition system are simple and straightforward and should pose little difficulty in trouble shooting. When a d-c indicator fails to operate properly, refer to the diagrams in Section VII (both the individual equipment schematics and the interconnecting circuit schematics) and to the applicable portions of paragraph 5-4 for information on isolating and ascertaining the source of trouble. The source of the trouble will in most instances be obvious on examination of the circuits involved. For information on inter-equipment wiring, refer to Section II, and for information on the internal wiring of equipment, refer to the applicable equipment manual.

B. SYNCHROS

This paragraph comprises three sections: criteria for distinguishing actual troubles (requiring repair or replacement to correct the malfunction) from those malfunctions which can be corrected by adjustment; system trouble analysis; and circuit trouble analysis. The material on system trouble analysis provides information to aid in isolating the trouble to a particular circuit, or portion of the system. The material on circuit trouble analysis will aid in further isolating and determining the exact nature of the trouble. Both the system and circuit trouble analyses are concerned with actual troubles, not misadjustments. For synchro adjustment procedures, refer to paragraph 5-4. B.

(1). CRITERIA FOR DISTINGUISHING TROUBLE FROM MISADJUSTMENT

A synchro device is not operating properly when it does not accurately, rapidly, and smoothly transmit or follow the angular information which is fed into it. If a synchro has an error in the information it puts out, but the error is small and constant and the output of the synchro follows the input smoothly and rapidly, the cause of the improper operation is most likely misadjustment. (For a transmitter the input is mechanical and the output is electrical. For a receiver the input is electrical and the output mechanical. For a control transformer there are two inputs, one electrical and one mechanical, and one output, electrical.) If the synchro follows the input but with changing error, does not follow the input, spins, oscillates, hunts, follows erratically, has a large error (about 60 degrees or more), hums, overheats, or exhibits a combination of these or similar symptoms, the cause is most likely an actual trouble, either in the synchro being observed, another synchro connected to it, or the circuits between the two.

(2). SYSTEM TROUBLE ANALYSIS

Trouble shooting of the synchros in the acquisition system requires a thorough knowledge of the basic principles of synchros and the particular way in which they are used in the system. (Refer to Section IV.) With this knowledge it should be evident from the pertinent schematics, especially figure 5-8 and the interconnecting schematics in section VII, what the possible causes are for any given trouble. However, keep the following points in mind:

(a). A defective synchro can degrade the performance or cause abnormal operation of any or all synchros which are connected directly to it; for instance, where two receivers (or a receiver and a control transformer) are wired in parallel, a defect in one of them may cause abnormal operation of both. In cases where several synchros have abnormal operation, it will help in isolating the trouble to disconnect, one at a time, each of those involved to see which is affecting the operation of the others.

(b). The reference voltage (rotor) circuits are virtually the only circuits the azimuth and elevation channels have in common. If abnormal operation shows up in both azimuth and elevation channels in a portion of the acquisition system, look for trouble in the reference voltage circuits.

(c). Troubles that show up just after installation or replacement of synchro units are most likely due to incorrect wiring connections, not to defective units.

(d). When a trouble occurs, be sure to check all connecting circuits very thoroughly. Synchros themselves, although delicate, are generally very reliable and trouble-free devices.

(3). <u>CIRCUIT TROUBLE ANALYSIS</u>

Once it has been determined that the source of trouble is in a particular circuit or portion of the system, circuit trouble analysis may be performed by one or a combination of the following means:

(a). Use of the synchro trouble shooting chart, figure 5-1: This chart graphically shows the symptoms and causes of most of the common synchro troubles, including incorrect wiring connections.

(b). Checks of connecting circuits: All of the circuits between synchros in a malfunctioning portion of the system should be checked in accordance with the applicable portions of paragraph 5-4 and the active acquisition aid equipment manual.

(c). Synchro voltage checks: In some instances it may not be possible to turn the suspected synchros as is necessary when using figure 5-1. In such instances the synchro voltages can be checked. Transmitter and receiver rotor voltage should always be 115 VAC. Transmitter, receiver, and control transformer stator voltages should be as shown by the curves of figure 4-6. Control transformer rotor voltage should be as shown in figure 4-11.

5-4. ADJUSTMENTS AND REPAIR

A. GENERAL

This paragraph describes, on an individual basis, adjustment and repair procedures for synchros and indicator assemblies. For detailed information on other components of the acquisition system, refer to the applicable equipment manual. The repair procedures given here are based on the assumption that a particular component, such as a synchro, is known or suspected to be malfunctioning. The procedures are for the isolation and correction of the specific cause of trouble. For general, or system, trouble shooting procedures, refer to paragraph 5-3.

B. SYNCHRO ALIGNMENT

(1). GENERAL

(a). This paragraph describes procedures for alignment and zeroing of synchro transmitters, receivers, and control transformers individually and while operating in a system.

(b). In a general sense, "zeroing" a synchro means adjusting it mechanically so that it will work properly in a system with one or more other synchros. Specifically, "zeroing" means aligning the mechanical and electrical zero positions of a synchro. Mechanical zero of a synchro is defined as the rotor position at which the mechanical device coupled to the synchro is at its zero position. For instance, a synchro transmitter coupled to the elevation drive of an antenna is at mechanical zero when the antenna is at zero degrees elevation; and a synchro receiver driving an azimuth indicator is at mechanical zero

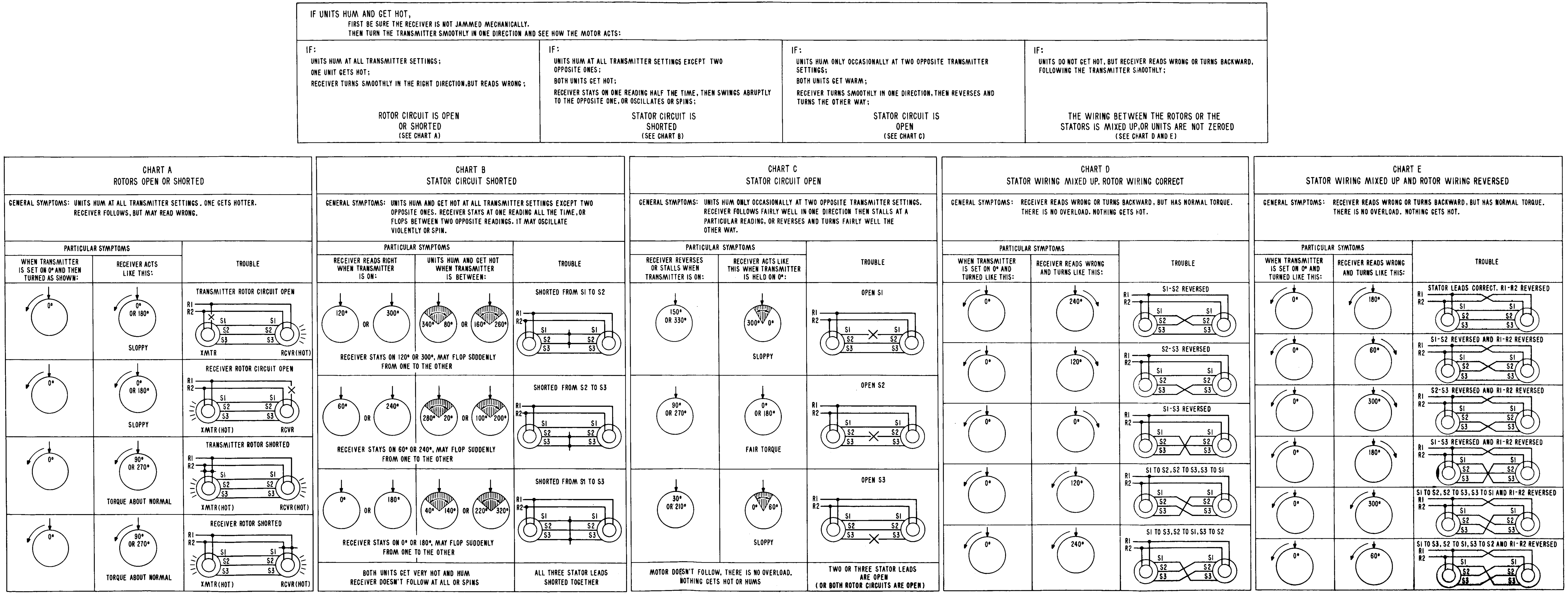


Figure 5-1. Synchro Troubles and Symptoms

when the indicator pointer or dial reading is zero degrees azimuth. Electrical zero of a synchro is defined as the position of the rotor when rated voltage is applied to the rotor, when there is no voltage difference between S1 and S3, and when rated voltage is applied between S2 and S1-S3 in such a way that the voltage at S2 (measured with respect to S1-S3) is in phase with the voltage at R1 (measured with respect to R2). The applied voltages and the rotor position at electrical zero are shown in figure 5-2. The voltages shown are rated values for the synchros used in the acquisition system. For purposes of definition, the arrangement shown in figure 5-2 applies both to synchro transmitters and receivers, and it is actually used for zeroing receivers. However, since synchro transmitters in operating position are not free to turn, a more convenient zeroing procedure is described below. The electrical zero position of a control transformer is as described in paragraph 4-2. D. (2). and shown in figure 4-9.

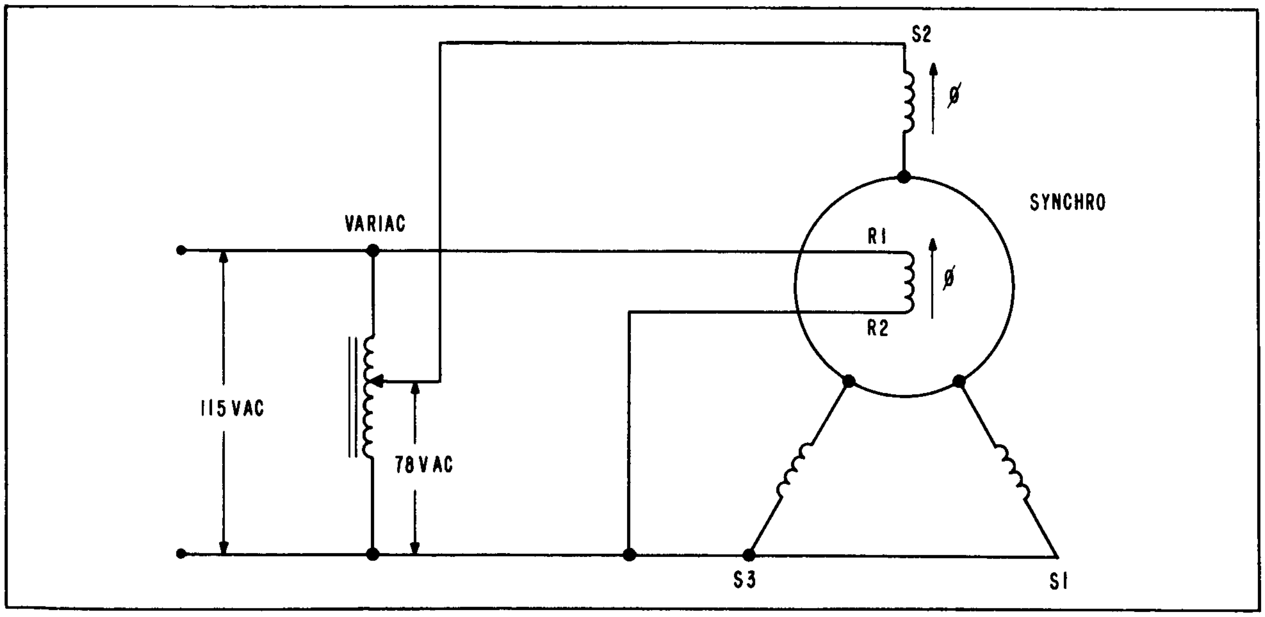


Figure 5-2. Conditions at Electrical Zero of a Synchro

(c). The procedures that follow comprise four sections; one for individual zeroing of transmitters, one for individual zeroing of receivers, one for individual zeroing of control transformers, and one for in-system alignment of transmitters and receivers. The first three sections apply, with some exceptions as noted, to any individual synchro transmitter, receiver, or control transformer, in the acquisition system.

(2). <u>SYNCHRO TRANSMITTERS</u>

The following are two procedures for zeroing synchro transmitters. The simplified procedure should be used when, but only when, the approximate electrical zero position of the transmitter is known. The reason for this restriction is that the simplified procedure is ambiguous; i.e., the null voltage for which the synchro is adjusted in the simplified procedure occurs at two positions, electrical zero and 180 degrees. The complete procedure allows the approximate position of electrical zero to be determined. Normally, it is not necessary to follow the complete procedure. Once the transmitter has been installed and is operating properly, the transmitter can be set approximately to electrical zero simply by setting the device to which it is mechanically coupled to zero azimuth or elevation.

(a). <u>TRANSMITTER ZEROING PROCEDURE — COMPLETE</u>

1. Set the device to which the synchro is mechanically coupled to its zero-degree position (azimuth or elevation).
2. Turn off reference voltage to the synchro (115 VAC).
3. Disconnect the stator leads (S1, S2, S3) from the synchro.
4. Connect a jumper between synchro terminals R2 and S2 and connect a voltmeter (Hewlett-Packard 400D, 300-volt scale) between terminals R1 and S1. (See figure 5-3.)

CAUTION

Before connecting the jumper between R2 and S2, make sure that the synchro has no internal jumpers which, when the external jumper is connected, would result in a short circuit of the 115 VAC power.

5. Apply 115 VAC to the rotor windings (R1 and R2) of the synchro:

<u>a</u>. If the meter reading is approximately 193 volts, the synchro is near electrical zero. Proceed with simplified

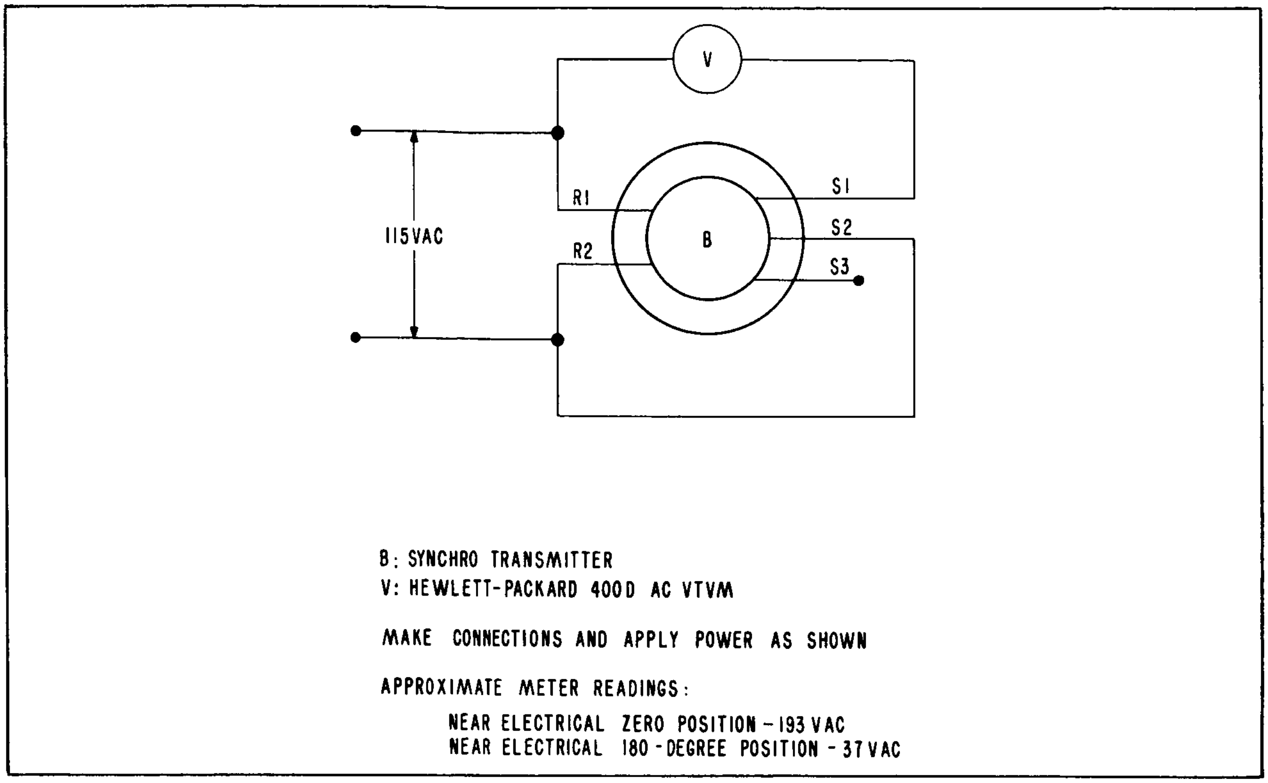


Figure 5-3. Method of Locating Approximate Position of Synchro Transmitter Electrical Zero

zeroing procedure below.

b. If the meter reading is approximately 37 volts, the synchro is near electrical 180 degrees. Turn off the 115 VAC reference, loosen the screws which hold the case, and turn the case of the synchro halfway around so that the meter reading is approximately 193 volts. Then proceed with the simplified zeroing procedure below.

c. If the meter reading is something roughly midway between 37 and 193 volts, the synchro is not near either zero or 180 degrees. Proceed with the simplified zeroing procedure to set the synchro near zero or 180 degrees. Then repeat the complete zeroing procedure.

(b). TRANSMITTER ZEROING PROCEDURE — SIMPLIFIED

1. Set the device to which the synchro is mechanically coupled to its zero-degree position (azimuth or elevation).

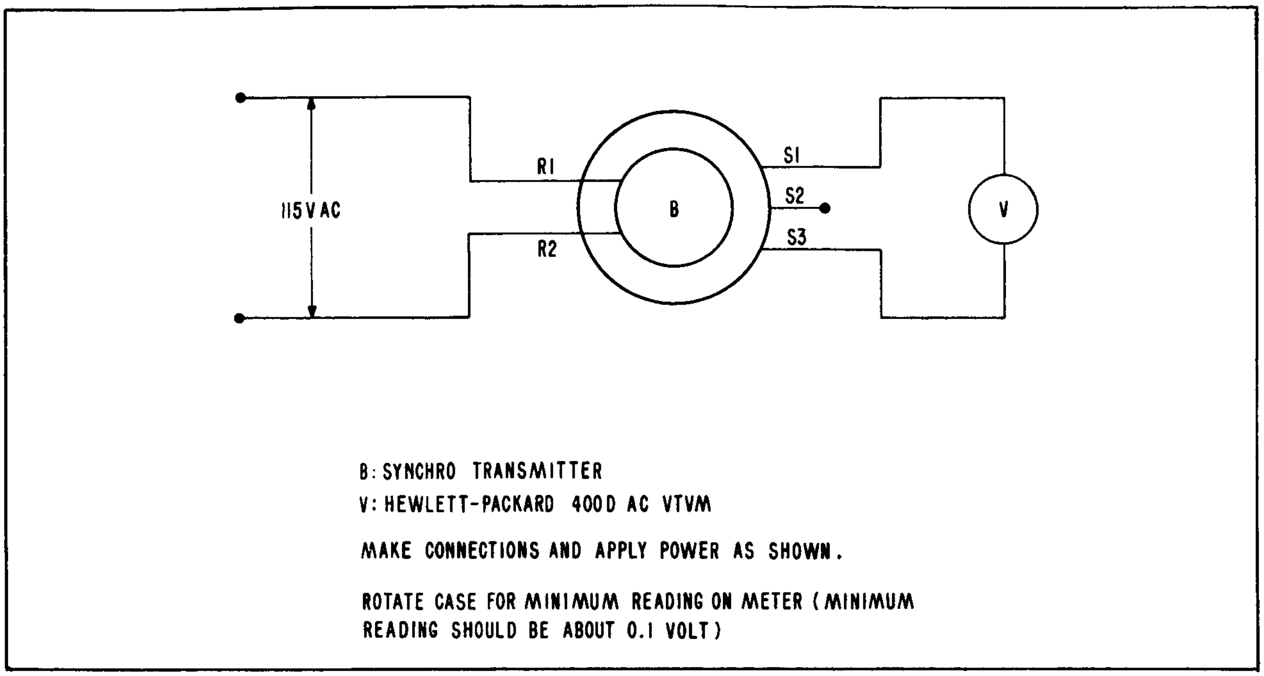


Figure 5-4. Method of Zeroing Synchro Transmitter

Note

> See paragraph 5-4. B. (2). for restrictions on the use of this procedure.

2. Turn off reference voltage (115 VAC) to the synchro.
3. Disconnect the stator leads (S1, S2, S3) from the synchro.
4. Connect a voltmeter (Hewlett-Packard 400D) between synchro terminals S1 and S3. (See figure 5-4.) To protect the meter, set it initially on the 100-volt scale. As lower voltage readings are obtained during the following steps of the zeroing procedure, set the meter to successively lower scales.
5. Loosen the screws which hold the case of the synchro so that the case is free to turn.
6. Apply 115 VAC to the rotor windings (R1 and R2) of the synchro.
7. Turn the case of the synchro in the direction which results in a decreasing meter reading. When a very low voltage reading is obtained, rotate the case of the synchro back and forth to

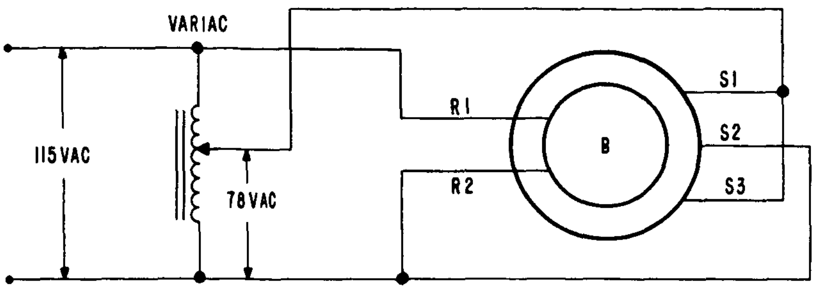


Figure 5-5. Method of Zeroing Synchro Receiver

locate the position of null voltage on the meter. (Null voltage should be about 0.1 volt.) This position is the electrical zero of the synchro.

8. With the synchro set at electrical zero, tighten the screws which hold the case in place.

9. Turn off the reference voltage (115 VAC) and reconnect stator leads (S1, S2, S3).

(3). <u>SYNCHRO RECEIVER ZEROING PROCEDURE</u>

(a). Turn off the reference voltage (115 VAC) to the synchro.

(b). Disconnect the stator leads (S1, S2, S3) from the synchro.

(c). Connect a variac (General Radio Type W10MT) as shown in figure 5-5.

(d). Turn on the 115 VAC reference voltage and adjust the variac for 78 VAC between synchro terminal S2 and terminals S1-S3. The synchro will turn to electrical 180 degrees.

(e). Being careful not to short circuit the 115 VAC voltage, loosen the screws which hold the case of the synchro and turn the case so that the synchro pointer or dial is at 180 degrees.

(f). Turn off the 115 VAC voltage and tighten the screws which hold the synchro case in place. The synchro is now zeroed.

Note

The synchro receivers on the radar display panel are so constructed that they cannot be zeroed by turning the case; the pointer must be turned on the rotor shaft. Partially disassemble the synchro and remove the pointer from the rotor shaft in accordance with the instructions in paragraph 5-4. C.

(4). CONTROL TRANSFORMERS

Two procedures, one complete and one simplified, for zeroing control transformers are given below. As was discussed for the case of synchro transmitters in paragraph 5-4. B. (2)., the simplified procedure should be used only when the approximate electrical zero position of the control transformer is known. However, in practice the approximate electrical zero position usually is known and the simplified procedure can, in most cases, be used.

(a). CONTROL TRANSFORMER ZEROING PROCEDURE — COMPLETE

1. Set the device to which the control transformer is mechanically coupled to its zero-degree position.

2. Disconnect the rotor (R1, R2) and stator (S1, S2, S3) leads from the control transformer.

3. Connect a jumper between terminals R2 and S3 and connect a voltmeter (Hewlett-Packard 400D, 300-volt scale) between terminals R1 and S1. (See figure 5-6.)

4. Connect a variac (General Radio Type W10MT) between terminals S1 and S3 as shown on figure 5-6 and apply 90 VAC to these terminals.

a. If the meter reading is approximately 30 volts, the control transformer is near electrical zero. Proceed with the simplified zeroing procedure below.

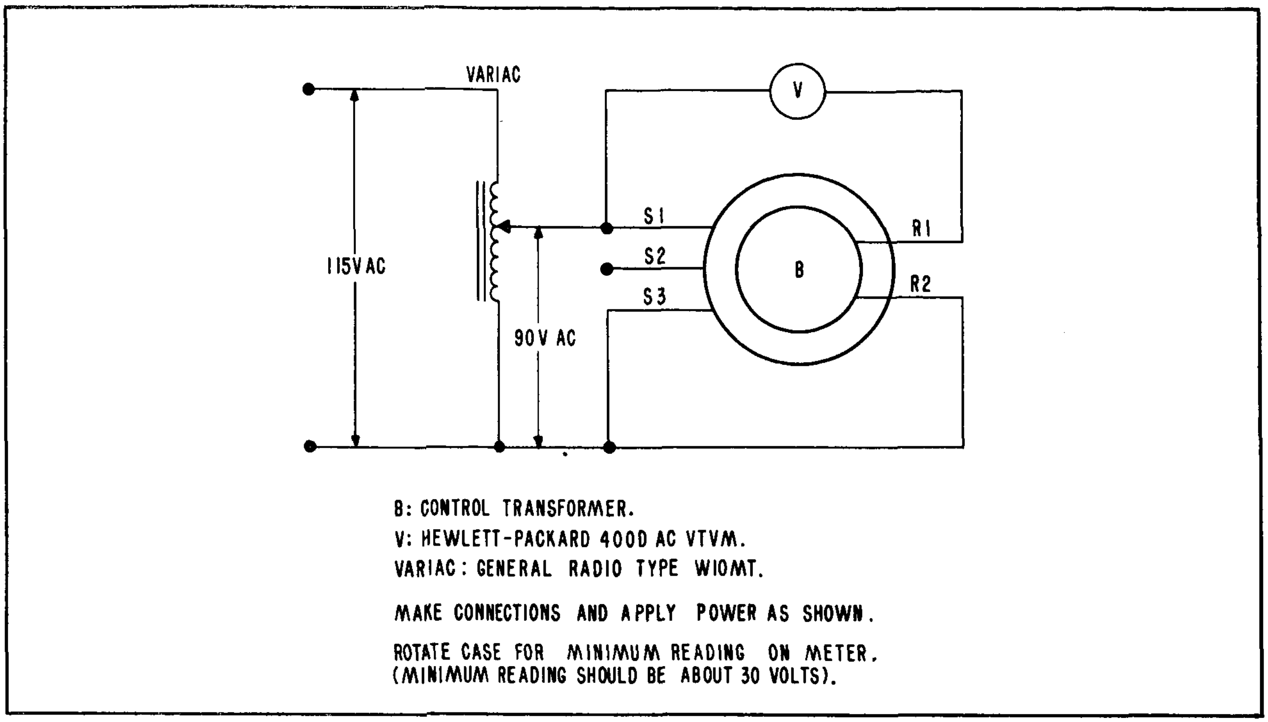


Figure 5-6. Method of Locating Approximate Position of Control Transformer Electrical Zero

b. If the meter reading is approximately 120 volts, the control transformer is near electrical 180 degrees. Turn off the power, loosen the screws which hold the case, and turn the case of the control transformer half way around. Turn the power back on; the meter reading now should be approximately 30 volts. Proceed with the simplified zeroing procedure.

(b). CONTROL TRANSFORMER ZEROING PROCEDURE — SIMPLIFIED

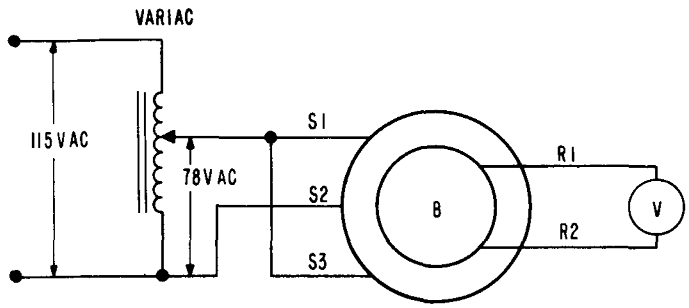
1. Set the device to which the control transformer is mechanically coupled to its zero-degree position.

Note

See paragraph 5-4. B. (4). for restrictions on the use of this procedure.

2. Disconnect the rotor (R1, R2) and stator (S1, S2, S3) leads from the control transformer.

3. Connect a jumper between terminals S1 and S3 and connect a voltmeter (Hewlett-Packard 400D) between terminals R1 and R2. (See figure 5-7.) To protect the meter, set it initially on the 100-volt scale. As lower voltage readings are obtained during the following steps of the procedure, set the meter to successively lower scales.



B: CONTROL TRANSFORMER.
V: HEWLETT-PACKARD 400D AC VTVM.
VARIAC: GENERAL RADIO TYPE W10MT

MAKE CONNECTIONS AND APPLY POWER AS SHOWN.

ROTATE CASE FOR MINIMUM READING ON METER. (MINIMUM READING SHOULD BE ABOUT 0.1 VOLT).

Figure 5-7. Method of Zeroing Control Transformer

4. Loosen the screws which hold the case of the control transformer so that the case is free to turn.
5. Connect a variac between terminals S1 and S2 as shown in figure 5-7 and apply 78 VAC to these terminals.
6. Turn the case of the control transformer in the direction which results in a decreasing meter reading. When a very low voltage reading is obtained, rotate the case of the control transformer back and forth to locate the position of null voltage on the meter. (Null voltage should be about 0.1 volt.) This position is the electrical zero of the control transformer.
7. With the control transformer set at electrical zero, tighten the screws which hold the case in place.
8. Turn off power and reconnect the control transformer for normal operation in its circuit.

(5). SYSTEM ALIGNMENT

In a system consisting of a synchro transmitter and a synchro receiver or control transformer, there are three places where misalignment errors commonly arise. These three are the transmitter, the receiver, and the circuits which connect the transmitter to the receiver. When the connecting circuits consist simply of cabling and/or fixed transformers, no adjustments can be made to them; errors can be corrected only at the transmitter or receiver. In a simple system consisting of a single transmitter and receiver or control transformer (a control transformer for the purposes of this discussion being equivalent to a synchro receiver), a misalignment error can be corrected by adjusting either one of the two elements (transmitter or receiver). In such a simple system it is immaterial where the source of error actually is; a misadjustment of the transmitter can be compensated for by adjusting the receiver to introduce an equal and opposite error. The only criterion for proper operation is that when the device which drives the synchro transmitter is pointing at a given angle, the synchro receiver indicates that angle. However, the synchros in the acquisition system are not all in a simple arrangement like that just described, and although short-cut methods can and should be used as the technician becomes familiar with the configuration and characteristics of the system, the general procedure given below should be followed in most cases:

(a). When an error is noted in the synchro system, determine if possible whether the error is due to a "trouble" or a misadjustment. The criteria for making this determination are discussed in paragraph 5-3.

(b). Isolate the source of the error as much as possible. That is, where there is more than one receiver connected to a transmitter, check all of the receivers to see whether the error shows up on all or on only one; switch between two transmitters which can be connected to a single receiver. (See figure 5-8. This illustration is a schematic of both the azimuth and elevation synchro systems, which are virtually identical.)

(c). Individually check the adjustment of each of the units (transmitters, receiver, and control transformer) for possible source of the particular error. Careful adjustment of the individual units should correct the majority of system errors. Individual check and adjust-

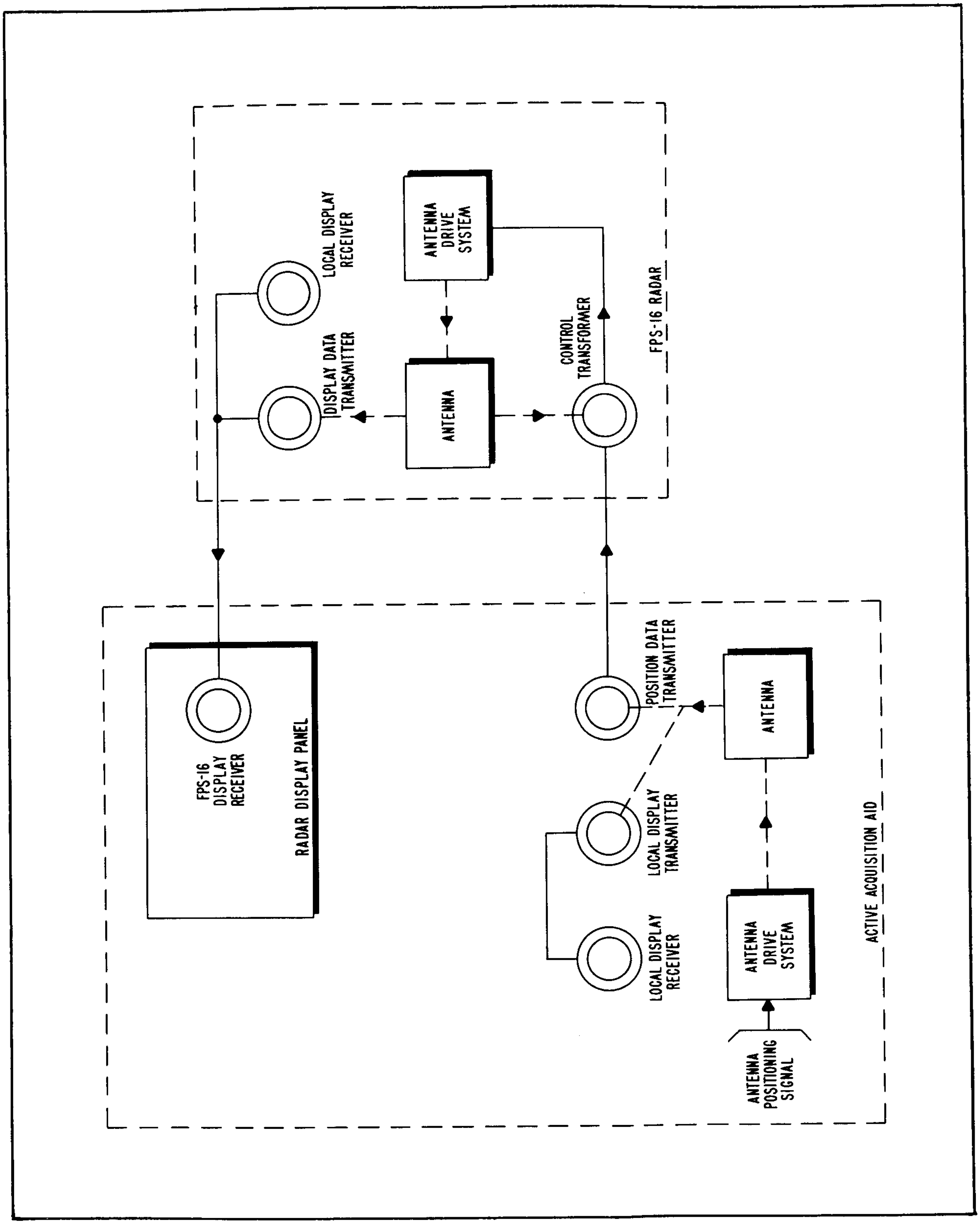


Figure 5-8. Azimuth and Elevation Synchro System, Schematic Diagram

ment procedures for synchro transmitters and receivers and control transformers are given in paragraphs 5-4. B. (2). , (3). , and (4).

(d). When all of the individual units involved have been properly adjusted and the error still persists, its source must be in the connecting cabling. An error arising in the cabling, so long as it is constant at all angular positions of the synchros, can be compensated for by introducing equal and opposite errors into the synchro receivers. Thus, when individual adjustment of the units of the system does not correct the error, system alignment should be made as follows:

1. Do not change the synchro transmitter; i.e., leave this unit as it was set in accordance with the individual adjustment procedure.
2. Set the device mechanically coupled to the transmitter to a known position (azimuth or elevation).
3. For synchro receivers, loosen the screws which hold the case and with the synchros energized (115 VAC applied) turn the case so that the receiver indication is the same as the position of the antenna.

Note

The case of the synchro receivers on the radar display panel cannot be turned; the pointer must be turned on the rotor shaft. Refer to the note in paragraph 5-4. B. (3).

4. Before adjusting a control transformer to compensate for errors introduced by interconnecting cabling, be sure that changing the setting of the control transformer will not introduce an error into the positioning system with which the control transformer is associated.

C. <u>SYNCHRO REPAIR</u>

(1). <u>REPAIR PROCEDURES</u>

(a). It is recommended that major repairs on synchro devices (transmitters, receivers, and control transformers) not be attempted in the field. However, minor repairs such as replacing broken pointers or dial plates and repairing broken connections (where wiring is accessible) can be made. For information on replacement of defective parts or gaining access to internal wiring of synchros on the radar display panel, refer to the disassembly and assembly procedures below. For information on other synchros in the acquisition system, refer to the applicable equipment manual.

(b). When there is a question as to whether a synchro is defective and requires replacement, the winding resistances should be checked. For the synchros on the radar display panel the d-c resistance of the stator windings (S1-S2, S2-S3, and S1-S3) should be about 95 ohms at room temperature, and the d-c resistance of the rotor winding (R1-R2) should be about 85 ohms at room temperature. For synchros in other equipment, comparable d-c resistance measurements should be obtained. (When a resistance measurement is doubtful, compare the resistances of corresponding windings in two identical synchros, or two windings of the same synchro.)

(2). <u>DISASSEMBLY</u>

The disassembly procedure described in this paragraph applies to the synchro receivers on the radar display panel. See figure 5-9.

(a). Dismount the synchro from the panel by removing the four mounting screws and nuts.

(b). Remove the eight screws which hold the bezel onto the front housing. Remove the bezel, dial plate and gasket and set them aside.

(c). Pull or pry the pointer off the end of the rotor shaft. As shipped from the factory the pointer is secured to the shaft with a drop of glue, and considerable force may be necessary to remove it. However, care should be exercised not to damage the fragile pointer during removal.

(d). Pull out the retaining ring and remove the dual.

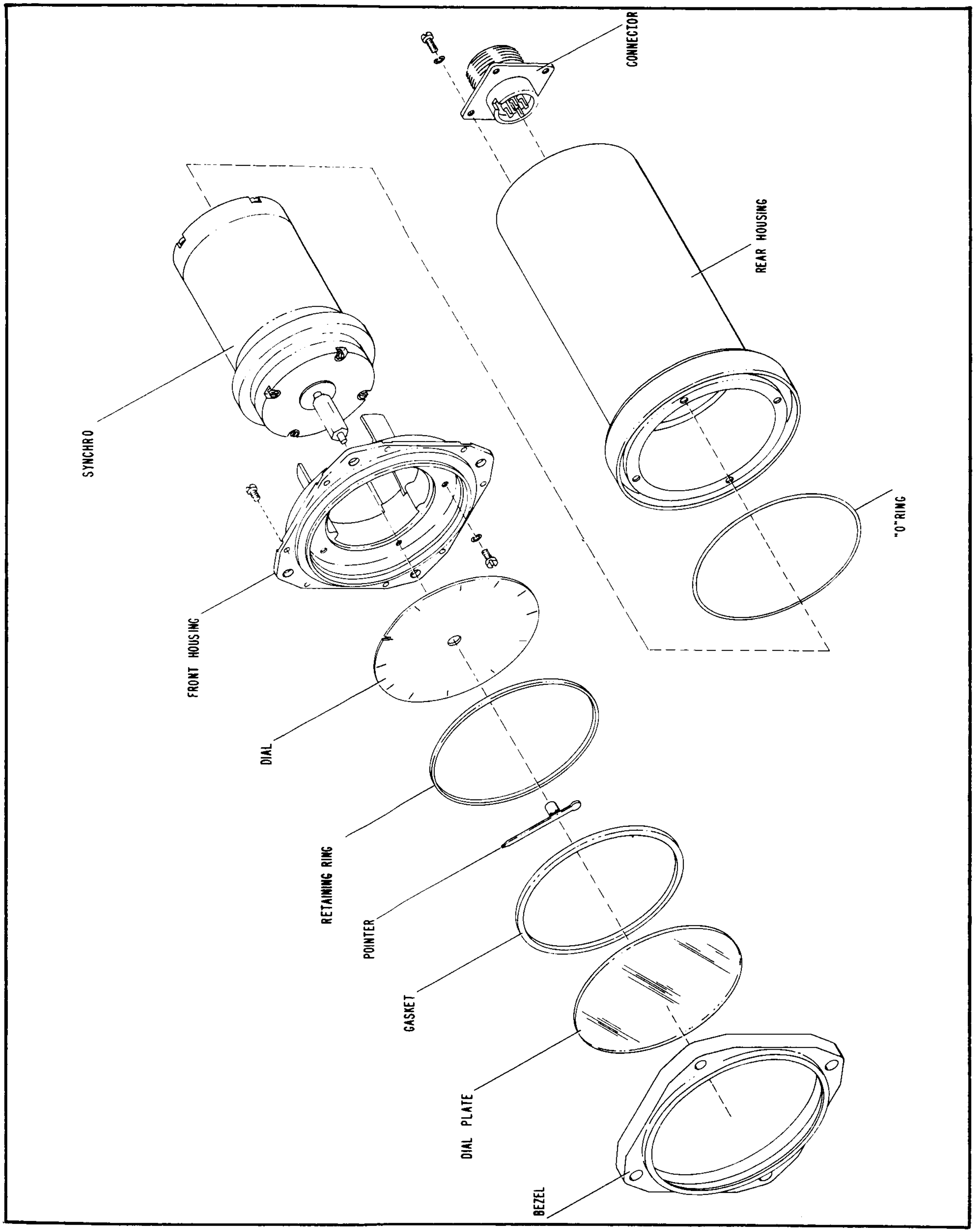


Figure 5-9. Radar Display Panel Synchro Receiver, Exploded View

(e). Remove the four screws which hold the front and rear housings together. Remove the front housing and "0" ring. With the front housing removed, only the wires from the connector to the synchro itself hold the synchro in the rear housing. Do not hold the rear housing in such a position that the connecting wires support the weight of the synchro.

(f). Remove the four screws which fasten the connector to the rear housing.

(g). Pull the connector as far away from the rear housing as the wiring permits and unsolder the wires from the connector pins. Drop the synchro itself out of the rear housing. This is as far as field disassembly should proceed.

(3). ASSEMBLY

Assembly of the synchro receivers on the radar display panel is the reverse of the disassembly procedure, except that particular attention should be paid to the pointer. Be sure that the pointer is replaced at the proper angle on the rotor shaft (refer to paragraph 5-4. B. (3).) and if necessary crimp the pointer socket slightly to obtain a secure fit on the rotor shaft.

D. RELAYS

(1). Relays used on the radar display panel are hermetically sealed, and no maintenance or repair is possible. When one of them becomes defective, replace it. To ascertain that a console relay is defective, check the following.

(a). Coil resistance: D-c coil resistances should be as follows:

1. K6001: 1000 ohms.
2. K6010: 10.5K.

(b). Contacts: With all power off, check continuity between normally-closed contacts. With the suspected relay energized and voltage applied across the contacts, check for voltage drop across normally-open contacts. There should, of course, be none.

(2). For detailed information on relays in the acquisition system other than those on the radar display panel, see the applicable equipment manual.

E. D-C INDICATOR ASSEMBLY

For a description of the radar display panel d-c indicator assembly, refer to paragraph 4-2. C. (1). Maintenance of the indicator consists simply of replacing loose or defective lamps and color filters. Replacement of these items is most easily accomplished with the use of the special lamp-filter tool, figure 5-10 (Microswitch part number 15PA19).

5-5. LUBRICATION

Table 5-II is a lubrication schedule for the equipment in the acquisition system.

5-6. SPECIAL TOOLS

The only special tool required for maintenance of the acquisition system is the lamp-filter tool (Microswitch part number 15PA19, Bendix Radio part number A683836-1). This tool, shown in figure 5-10, is used for removal and replacement of the lamps and color filters in indicator assemblies.

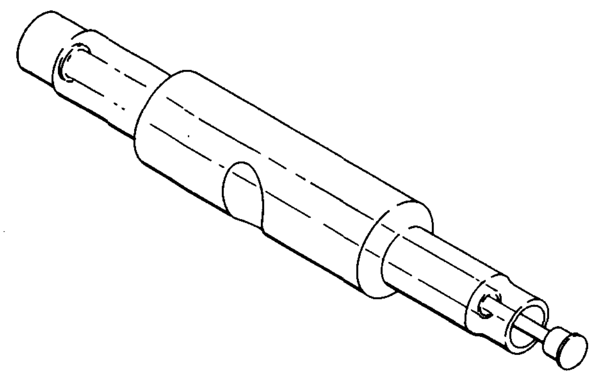


Figure 5-10. Lamp-Filter Tool

5-7. TEST EQUIPMENT

Each piece of test equipment required for maintenance of the acquisition system is listed in table 5-III along with a brief description of its application.

TABLE 5-II. LUBRICATION SCHEDULE

Lubrication Point	Procedure	Lubricant	Frequency
ACTIVE ACQUISITION AID			
Elevation Drive Assembly	Add oil as needed. Refer to equipment manual.	High grade SAE 10 nondetergent lubricating oil	Monthly
Azimuth Drive Assembly	Drain water from sump and add oil as needed. Refer to equipment manual.	High grade SAE 10 nondetergent lubricating oil	Weekly
Antenna Control Unit	Clean and relubricate gears. Refer to equipment manual.	High grade SAE 10 nondetergent lubricating oil and lubriplate.	As required
Muffin Fans in RF Housing	Lubricate with one or two drops of oil. Refer to equipment manual.	Aero Shell No. 12 (MIL-L-6085)	Monthly

TABLE 5-III. TEST EQUIPMENT APPLICATIONS

Equipment	Manufacturer	Model	Application
Oscilloscope	Tektronix, Incorporated	545A	General waveform observation and voltage measurements.
Dual-Trace Calibrated Preamp	Tektronix, Incorporated	Type CA	Oscilloscope plug-in unit used with Tektronix 545A.
Plug-In Preamplifier	Tektronix, Incorporated	Type L	Oscilloscope plug-in unit used with Tektronix 545A.
Viewing Hood	Tektronix, Incorporated	H510	Aid in viewing of oscilloscope screens.
Oscilloscope Cart	Technibilt Corporation	OC-2 (Bendix Radio P/N A683940-1)	Support and transportation of oscilloscopes and storage of plug-in units.
Unit Regulated Power Supply	General Radio Company	1201-B	General bench testing of assemblies. Provides a source of a-c heater voltage at 6.3 VAC and 4A, and d-c plate power at 300 VDC and 70 MA.
Regulated Power Supply	Lambda Electronics Corporation	71	General purpose power supply with following outputs: 0-500 VDC, 0-200 MA; 0-200 VDC, 0-50 VDC, Bias; and 6.5 VAC, 5A.
D-C Power Supply	John Fluke Manufacturing Company, Incorporated	407	High resolution power supply with output of 0 to 555 volts and 0 to 300 MA for calibration purposes.
Square Wave Generator	Tektronix, Incorporated	Type 105	Alignment and testing of oscilloscopes and associated plug-in units.
Signal Generator	Boonton Radio Corporation	225-A	Test and alignment of receivers, sensitivity and bandwidth measurements in the 10- to 500-MC frequency range.
Sweep Generator	Telonic Industries, Incorporated	HN-3	Testing and adjusting r-f circuits in the frequency range of 0.5 to 300 MC.
HF Signal Generator	Hewlett-Packard Company	606-A	General purpose signal generator with a frequency range of 50 KC to 65 MC.

TABLE 5-III. TEST EQUIPMENT APPLICATIONS (Cont.)

Equipment	Manufacturer	Model	Application
Function Generator	Hewlett-Packard Company	202-A	Test and adjustment of circuits which handle non-sinusoidal waveshapes.
Transfer Oscillator	Hewlett-Packard Company	540-B	Test and alignment of signal generators up to 2000 MC.
Wide Range Oscillator	Hewlett-Packard Company	200 CD	Test and adjustment of circuits in the range of 5 CPS to 600 KC.
Unit Oscillator	General Radio Company	1209-BL	Test and alignment of receivers, sensitivity and bandwidth measurements in the 180- to 600-MC range.
Universal EPUT and Timer	Beckman Instruments, Inc.	7370	Precision frequency measurements from 10 CPS to 11.5 MC.
Frequency Converter	Beckman Instruments, Inc.	7570 through 7573	Used with Beckman EPUT and timer to measure frequencies up to 220 MC.
Field Strength Meter	Empire Devices Products Corporation	NF-105 (Bendix P/N A683351)	Noise figure measurements in the 150-KC to 400-MC frequency range.
Microwave Power Meter	Hewlett-Packard Company	430C	Frequency power measurements of any range for which a bolometer mount exists. Direct reading from .01 to 10 MW, or from -20 to +10 DBM.
Potentiometric DC Voltmeter	John Fluke Manufacturing Company, Incorporated	801	Precision d-c measurements with .05 per cent accuracy over the range of .01 to 500 volts.
Vacuum Tube Voltmeter	Hewlett-Packard Company	410B	General a-c, d-c, and r-f voltage measurements and resistance measurements.
Vacuum Tube Voltmeter	Hewlett-Packard Company	400D	Accurate a-c voltage measurements from .001 volt to 300 volts over a frequency range of 10 CPS to 4 MC.

TABLE 5-III. TEST EQUIPMENT APPLICATIONS (Cont.)

Equipment	Manufacturer	Model	Application
Volt-Ohm Milliam-meter	Triplett-Electrical Instrument Company	630-PL	General voltage, current and resistance measurements, (20,000 ohms/volt).
Noise and Distortion Analyzer	Hewlett-Packard Company	330B	Measure total distortion of any frequency from 20 to 20,000 CPS.
RF Detector	Telonic Industries, Incorporated	XD-3	Detect output of r-f preamplifiers and i-f amplifiers in the 0.5- to 1000-MC range.
Tube Analyzer	Triplett-Electrical Instrument Company	3444	Tube checks.
Variac	General Radio Company	W10MT	General purpose voltage source with output of 0-115 VAC at 10 amps.
Attenuator Pad	Telonic Industries, Incorporated	TGC-50	Matching, isolation and general bench test applications in the 0.5- to 1000-MC frequency range.
Miscellaneous Cables and Accessories	—	—	—

SECTION VI
PARTS LIST

6-1. GENERAL

This section comprises a list of replaceable parts which make up the active acquisition aid control console radar display panel and the antenna drive power cutoff switch and warning light.

Equipment	Parts List Table
Active Acquisition Aid Control Console Radar Display Panel, P/N L654905-1	6-I
Antenna Drive Power Cutoff Switch and Warning Light P/N L653858-1	6-II

6-2. OTHER EQUIPMENT

For information on other equipment in the acquisition system, refer to the applicable equipment manual, listed in table 1-II.

TABLE 6-I. LIST OF REPLACEABLE ELECTRICAL PARTS FOR ACTIVE ACQUISITION AID CONTROL CONSOLE RADAR DISPLAY PANEL, P/N L654905-1

Reference Designation	Part Name and Description	Bendix Part No.	Part No. (MIL, JAN, or FSN)	Quan.
B6001	Synchro Receiver	N681819-3		1
B6002	Synchro Receiver	N681819-2		1
DS6001, DS6002	Lamp, GE327		AN3140-327	2
K6001	Relay, Sensitive, 1000 ohm, 4.5 MA (DPDT)	A683968-1		1
K6010	Relay, 115 VAC, 6PST	696740-1		1
P6001, P6002	Connector		MS3106A-14S-2S	2
R6001	Resistor, Fixed, 2400 ohms, 1/2W, 5%		RC20GF242J	1
X6001	Indicator Unit	A683961-2		1
	Lamps DS6001, DS6002			2
	Display Screen	A681848-2		1
	Color Filter (yellow)	A683911-2		2
	Barrier strips (used with indicator unit)	A681860-2		2

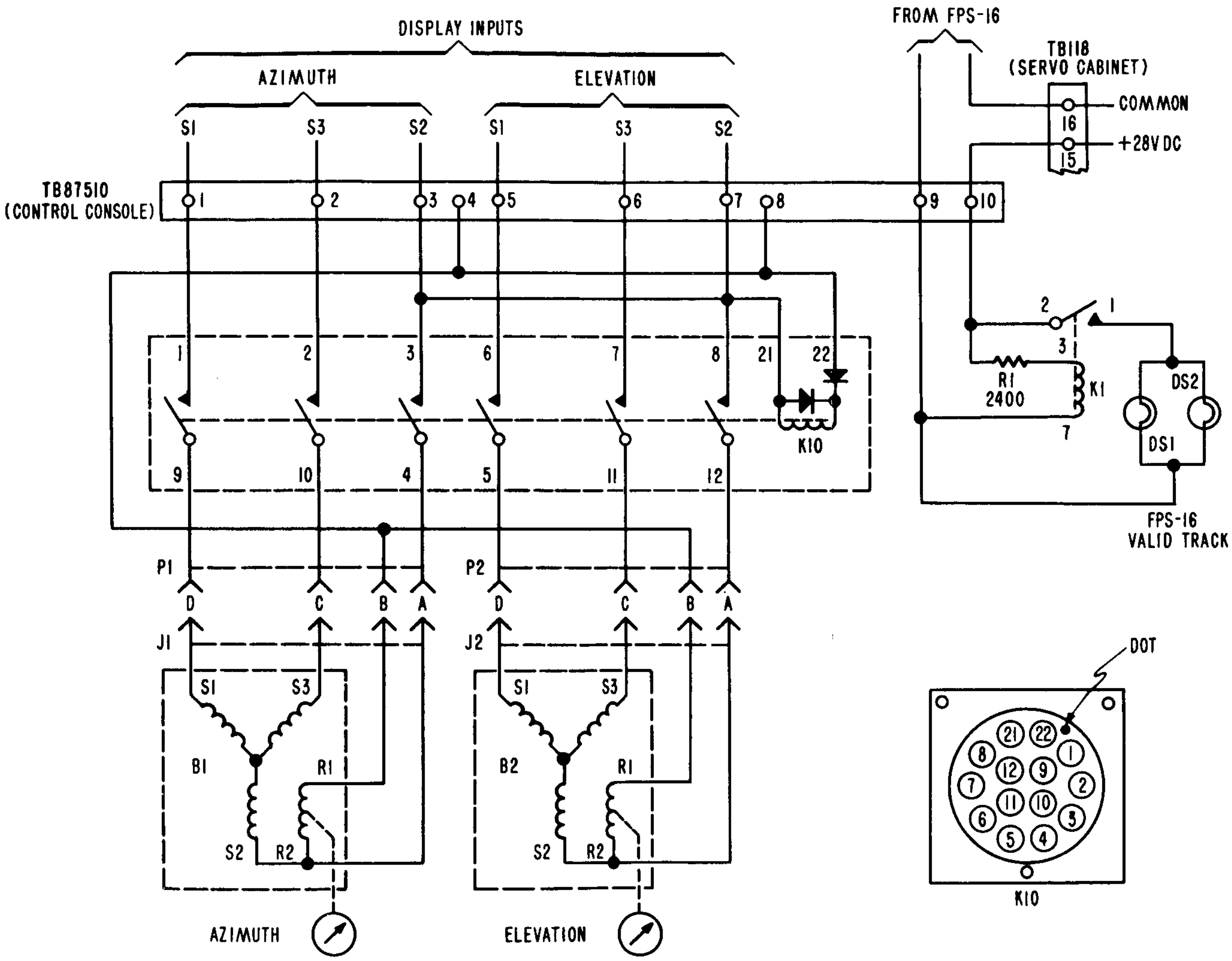
TABLE 6-II. LIST OF REPLACEABLE ELECTRICAL PARTS FOR CUTOFF SWITCH AND WARNING LIGHT ASSY., P/N L653858-1

Reference Designation	Part Name and Description	Bendix Part No.	Part No. (MIL, JAN, or FSN)	Quan.
	Switch and Box, ERTA 12022	A683229-1		1
	Warning Light Assembly	A683135-1		1
	Lamp, Incandescent	A120680-1		1
	Cable	689846-2		1

SECTION VII
MAINTENANCE DRAWINGS

7-1. GENERAL

The drawings included in this section are listed below. It should be noted that those schematics which show connections or circuits involving two or more separate pieces of equipment are not in all cases complete in regard to the internal circuits of the equipment. For complete internal circuits, see the schematics of the individual pieces of equipment. The individual equipment schematics are included in this section or in the individual equipment manual, listed in table 1-II.



NOTES—
1. ADD 6000 TO ALL REFERENCE DESIGNATIONS EXCEPT TB87510 AND TB118.
2. RELAYS SHOWN IN UNENERGIZED POSITION.

Figure 7-1. Active Acquisition Aid Control Console Radar Display Panel, Schematic Diagram

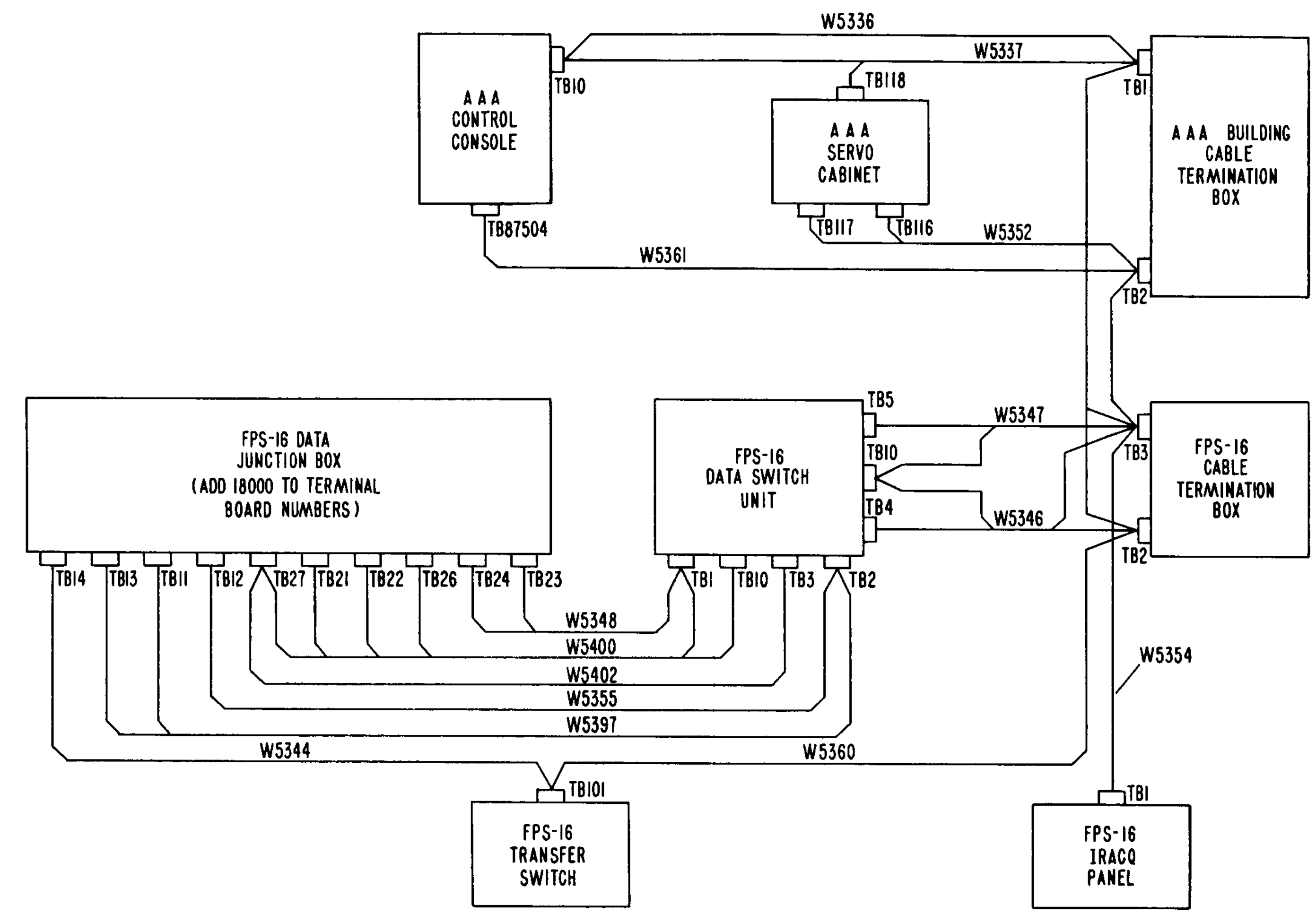
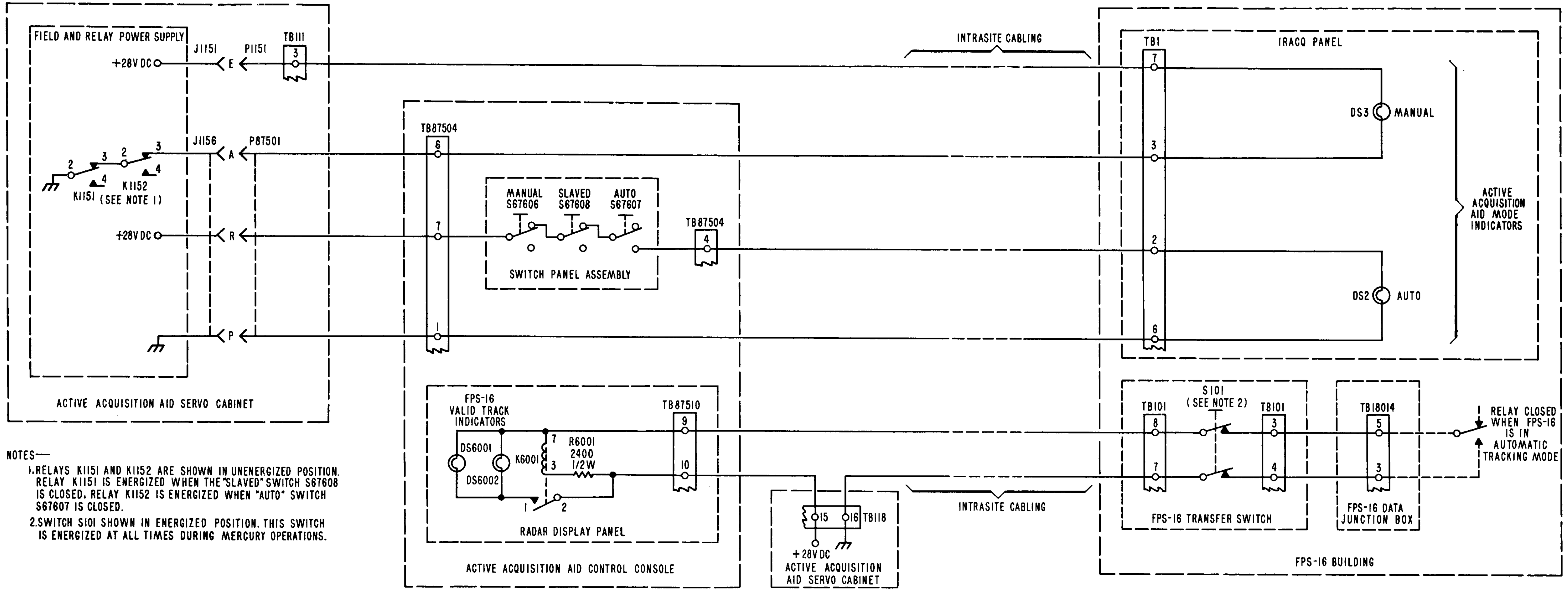
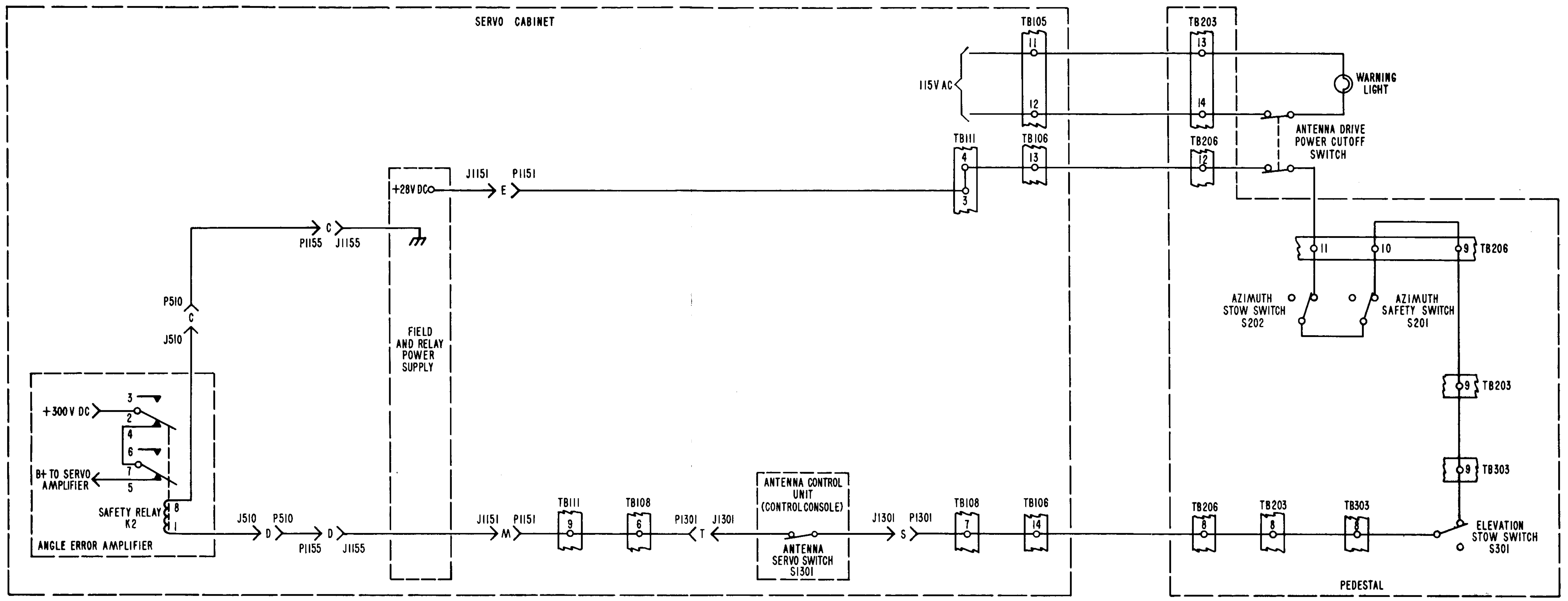


Figure 7-6. Acquisition System Interconnecting Cabling Diagram



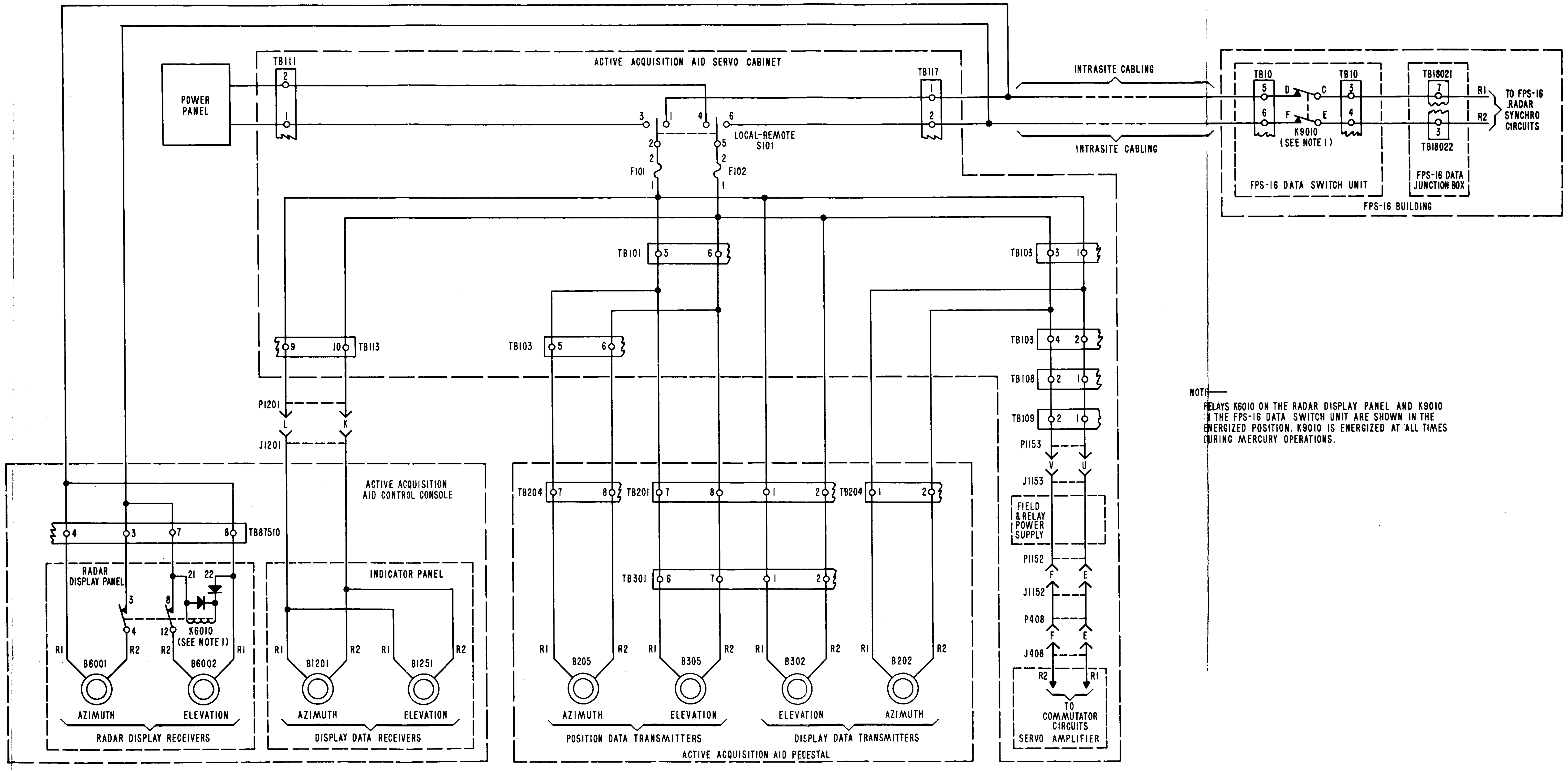
NOTES—
1. RELAYS K1151 AND K1152 ARE SHOWN IN UNENERGIZED POSITION. RELAY K1151 IS ENERGIZED WHEN THE "SLAVED" SWITCH S67608 IS CLOSED. RELAY K1152 IS ENERGIZED WHEN "AUTO" SWITCH S67607 IS CLOSED.
2. SWITCH S101 SHOWN IN ENERGIZED POSITION. THIS SWITCH IS ENERGIZED AT ALL TIMES DURING MERCURY OPERATIONS.

Figure 7-5. Acquisition System D-c Indications, Schematic Diagram



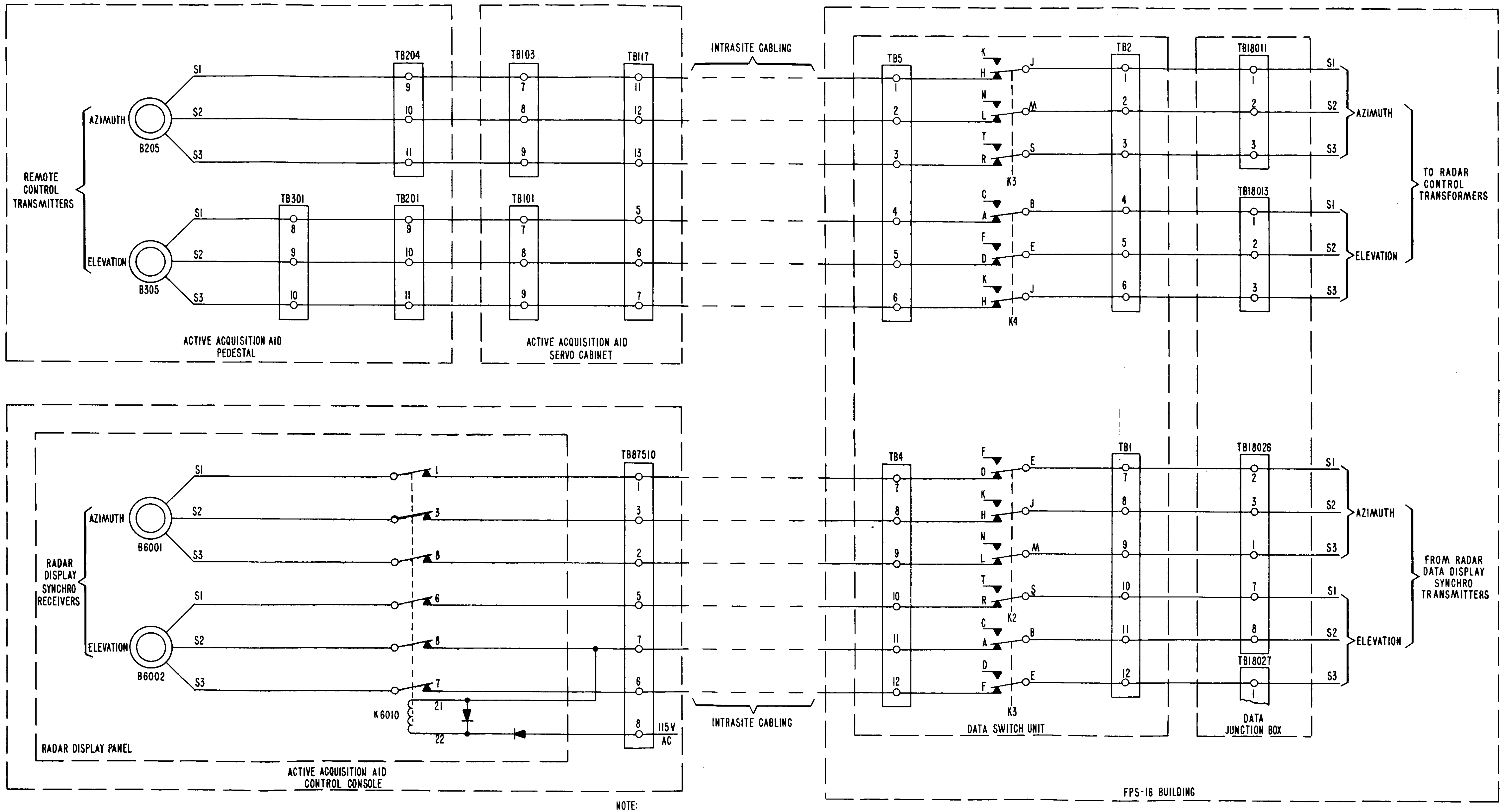
NOTES—
1. ALL SWITCHES SHOWN IN RUN (OPERATING) POSITION.
2. RELAY SHOWN IN ENERGIZED POSITION.
3. ANTENNA DRIVE POWER CUTOFF SWITCH AND WARNING LIGHT (ONE ASSEMBLY) ARE MOUNTED NEAR TOP OF LADDER LEADING TO ANTENNA PLATFORM.

Figure 7-4. Active Acquisition Aid Antenna Safety Circuit, Schematic Diagram



NOTE—
RELAYS K6010 ON THE RADAR DISPLAY PANEL AND K9010 IN THE FPS-16 DATA SWITCH UNIT ARE SHOWN IN THE ENERGIZED POSITION. K9010 IS ENERGIZED AT ALL TIMES DURING MERCURY OPERATIONS.

Figure 7-3. Synchro Reference Circuit Connections between Active Acquisition Aid and FPS-16 Radar, Schematic Diagram



NOTE:
RELAYS K2, K3, K4 AND K10 ARE SHOWN IN THE ENERGIZED POSITION.
RELAY K6010 IS ENERGIZED WHEN 115V AC REFERENCE IS APPLIED.
RELAYS K2, K3, AND K4 ARE ALWAYS ENERGIZED FOR MERCURY OPERATION.

Figure 7-2. Synchro Stator Circuit Connections between Active Acquisition Aid and FPS-16 Radar, Schematic Diagram